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THE ESSENTIALS OF PSYCHOLOGY

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THE ESSENTIALS OF PSYCHOLOGY

BY

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To the Memory of

E. C. P.

PREFACE

In revising this book for the second time since its publication nineteen years ago, my purpose has not changed essentially. It may still be said that 'the aim of the volume is to present clearly the accepted facts of psychology.' Emphasis is still upon fact rather than theory. The accepted attitude in the science as a whole has changed, however, so that while in the first edition apology was made for the objective mode of presentation adopted, now, if apology were to be made at all, it would be for retaining so much of the subjective approach. But many of the facts discovered by the older workers are important and they can be presented more clearly on the assumptions of their discoverers than by the more external form of statement. The book embodies the newest results, but does not turn its back upon the old.

In the present edition the greater part has been entirely rewritten. Much new material has been added to the chapter on the Nervous System, to the discussion of vision, of memory, of emotion, and of fatigue. The treatment of the much mooted problem of instinct has been entirely revised. It has been brought forward to constitute the fourth chapter and appears as a discussion of how much is native in movement. Little has been left as innate save the control of learning through selection. This chapter is followed by one devoted to motor learning as seen in the animal work and the conditioned reflex, and that by another on association. A final chapter prepares the student for

the divergences in point of view he will find in his later reading. This gives a very brief summary of the historical development of psychological theories, and a bare statement of the position of the more important schools at present struggling for recognition.

I desire to express my warm thanks to the individuals who have helped in the preparation of the manuscript. In addition to all those who aided with the earlier editions, I owe much to the suggestions of Professor Leuba of Bryn Mawr and to my colleagues here. Mr. Thuma drew Figure 5 and has given much help with the nervous system and vision. Mr. Billings provided the data for the note on correlations. Professor Ford has been helpful on many points, and Professor Adams read parts and suggested improvements in expression. My wife has been generous with help on the proofs.

I also desire to express my thanks for permission to use cuts. In addition to those acknowledged in the preface to earlier editions, D. Appleton & Co. has granted permission to use a cut from Cannon: *Bodily Changes in Fear, Hunger, Pain and Rage;* Van Nostrand & Co. to use a cut from Fletcher: *Speech and Hearing;* and Crowell & Co., a cut from Wheeler's *Science of Psychology.*

W. B. Pillsbury

Ann Arbor, Mich.,
April, 1930

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(1) It desires to understand the conditions of man's action. how he can work to best advantage reasons for his successes and failures.
(2) How individual becomes aware of the external world

ESSENTIALS OF PSYCHOLOGY

CHAPTER I

INTRODUCTION

The Problem of Psychology. — All are agreed that psychology is a study of man as an acting and knowing individual. It desires to understand the conditions of man's action, how he can work to the best advantage, and the reasons for his successes and failures. On the other hand, psychology is interested in determining how the individual becomes aware of the external world, how he retains his experiences and recalls them, how he reaches conclusions, the occasions and origins of his feelings and emotions, and the way he makes decisions. Not so general is the agreement as to the best words to use in defining the aims of psychology. One early definition was that psychology is the science of mind, a literal translation of the original Greek roots used in the name of the science. This was objected to by many because mind seems to imply something more substantial than direct observation justifies. Then consciousness was substituted for mind, but with no longer period of acceptance. Some were quite as ready to deny the existence of consciousness as of mind, and others thought that if it existed psychology was interested in much more than consciousness.

The Definition of Psychology. — We can obviate many objections if we define psychology in terms of the acts that

it studies, rather than of assuming that there are objects of a mental character that can be studied. To use technical terms we can agree as to the functions that are to be considered much more readily than upon structures. We can define psychology as the science of behaviour and of the knowing functions of man. This definitely asserts that psychology studies the behaviour of animals other than man, and at the same time makes it explicit that we intend to consider the problems connected with man's perceiving, remembering, and thinking as well as his mere objective behaviour. Taken in this way psychology has two partially distinguishable general functions as objects of its investigation, and two correspondingly different methods which can be applied to the study of each. The first one treats of the behaviour of the individual. This may be studied by purely objective methods, and in the animal as well as in the man. The second, so far as we have direct evidence, is restricted to man and may be studied directly by the individual who has the experiences, as well as objectively. The two sets of functions are not entirely distinct, for what we know has much to do with our behaviour, and the active life contributes a great many essential facts to increase our knowledge. In fact the two functions are so closely connected that were it not for the insistence of an important school that behaviour should be studied only objectively, one could very well define psychology as the science of behaviour.

The Methods of Psychology. — Objectively behaviour may be studied by putting the individual in different situations and keeping a record of how he responds. You can test him by giving him problems of increasing difficulty and determining how many of them he can solve. By varying

the problems one can measure in this way the different kinds of capacity, although in practice it has not been easy to classify abilities or the tasks that would measure them. One can and does vary the stimuli that are permitted to act upon an individual and determine how the responses vary with these changes in the stimuli. These methods will be developed in detail in the later chapters. Here we may be content to indicate that man can be studied by objective methods and laws of human behaviour be developed from them.

Note

Introspection. — When we are dealing with a man, it is always possible to supplement what we can learn of his acts from direct observation, by asking him to tell us what he is thinking of at the time, and, if he can, how these thoughts influenced his action. This is known as introspection. Several men in the past have questioned whether one could study one's own actions without interfering with them. If one is solving a puzzle or attempting to recall a name and at the same time wondering how the act is accomplished, it is asserted that the act itself is interfered with. The objection would hold were the two operations really carried on at the same time. As a matter of fact, introspection is always retrospection. It has long been known that each operation persists in memory for several seconds. This primary memory is much like a photograph in its fidelity to the event and may be studied like one. This after-effect is not at all disturbed by studying it. Introspection is possible, then, because one does not observe the act while it is actually going on, but examines it a moment later in memory. Observation in this primary memory is accurate and does not alter the process investigated. Observation in any natural science requires the same reliance on momen-

Note

Note

tary memory. One cannot at the same time make an observation and record it. If one tried, mistakes would be made. A thermometer reading, *e.g.* is taken and held in memory until recorded, and then still later it is interpreted or used in the explanation of related facts. Introspection is no more difficult or uncertain than is observation of external phenomena.

Experiment. — Within the last generation methods have been developed by which both introspection and observation can be carried on under experimental conditions and with the aid of instruments of precision. Experiment makes it possible to control accurately the conditions and antecedents of mental operations. It is possible now to remove from distracting stimuli the individual who is introspecting or being observed, to measure accurately the stimuli that are permitted to affect him, and to record his responses. It is a commonplace that a man who is embarrassed will blush. Delicate physiological instruments used in the psychological laboratory show that the blush is only a heightened effect of the changes in circulation that take place in all parts of the body in connection with almost all mental processes. Similarly it was first observed with the unaided eye that the eyes move by jumps during reading. Later it was found possible to photograph the movements of the eyes, and these results brought out important laws that could not have been known otherwise. Introspection as well as observation has been greatly aided by measuring the time that elapses between a stimulus and the response that it occasions and between different parts of the same process. Many relations unnoticed before have become known through a study of these temporal successions and values. Even if experiment may be regarded as primarily

a means of increasing the accuracy of observation and introspection, it has through its wide application made possible important advances in nearly every field of psychology. To its great benefit psychology has become an experimental science.

Statistics as a Psychological Method. — Another method that has been much used recently in the study of psychological problems is statistics, or the study of measurements of different acts and characteristics of masses of men. If one would know whether any capacity is inherited, one can learn only by comparing the results from a large number of parents, with those obtained by the same method from a large number of their children. Special mathematical methods have been developed for the study of this and similar problems. Many stimuli that are too slight in their effects to be noticed, certainly on a single individual, may have a measurable influence when studied on a large mass. Thus one can determine whether size or frequency of repetition is more effective in attracting attention by making experiments upon a large number of individuals, or can actually keep a record of returns from a large number of advertisements, of different sizes run once, or of the same size run a large number of times in the same periodical, and comparing the results. Most problems that involve measurements of ability or the determination of the way abilities are related or may be used to the best advantage must be studied on large masses and by the use of statistical methods. Statistics has become almost an independent method in psychology.

Tests. — A method much used in the practical applications of psychology is the test. A test is a brief experiment that may be applied to a man very quickly or to a

large number of men at once. Tests have been developed that give measurements of different capacities. More widely used and first developed were tests of general ability, that can be applied to all ages and conditions of men. Tests also have been elaborated in recent years until they constitute almost a distinct branch of psychology.

Psychology and the Nervous System. — A complete understanding of the causes of man's action requires more knowledge than can be obtained by observation and introspection combined, even when aided by experiments and statistics. In addition one must know something of the mechanism of the body, particularly of the nervous system. The observer sees the occasion for action and notes the response; the actor sees the object and feels the response, but neither knows what happens in between nor appreciates fully the conditions of the act. For example, a wasp approaches, the man draws back or strikes. The observer notes the occasion for the movement and the movement itself, but nothing more. The man attacked sees the wasp and knows that he is moving or has moved, but nothing more. Neither can know why the movement takes place. One sees the stimulus vanish into the physical organism and movement result; the other sees the insect, moves, and all the time is perturbed by an emotion, but neither can absolutely foresee the act, neither knows why it comes. One can really understand the action only if one knows the course of the stimulus from the sense organ through the nervous system to the muscle that responds. This knowledge is supplied by the anatomy and physiology of the nervous system, to which psychology must appeal. A long chapter is devoted to a summary of these topics, for we cannot assume a knowledge of them in advance. Human

behaviour, then, can be understood by careful, long-continued observation of man in action from the inside and from the outside, and by relating the results of these observations to the earlier experiences of the individual and to the facts concerning the nature and action of the nervous system established by the anatomist and the physiologist.

Relation of Psychology to Other Sciences. — The relations of psychology to the other sciences are particularly close and important. The biological sciences shade over into psychology so gradually that it is not always possible to decide whether a problem belongs to psychology or to one of the biological sciences. The sciences that explain the nature and action of the human body, the sciences of anatomy and physiology, merge gradually into psychology. One can not understand behaviour unless one knows something of the living organism, of the sense organs that receive the impression from without, of the muscles that produce the actions, and of the nervous system that connects them. From the outside one can understand man's behaviour most fully and easily by comparing it with the behaviour of animals and tracing the gradual development of man's action in connection with the simpler forms of animal behaviour. Experimental biology gradually shades over into experimental psychology. The biologist has recently been devoting himself to the problems of animal behaviour. The light cast upon human conduct by these experiments is only less important than that cast upon the actions of animals themselves. Still more general results of biological science have been profoundly important for the explanation of human consciousness. The very general acceptance in recent times of the doctrine of evolution has forced us to

read the story of mind in the light of the development of the human organism from the lower forms of life. The result is a very much fuller understanding of many of the more fundamental phases of human activity. All of the physical sciences furnish some material for the psychologist, since the sense processes can be understood only in connection with the physical forces that act upon the organism.

The Social Sciences. — In addition to the sciences from which it receives material and methods, psychology has come into a position where it may offer help to many sciences. If psychology can give information concerning human behaviour, it is evident that all the human and social sciences may look to it for aid in the solution of their problems. Sociology, or the study of man in the group, evidently must found its results upon a study of the individual. In less degree, history, when it seeks to trace connections between its observed facts, must look to psychology for its fundamental principles. Economics, too, works with psychological materials. Its fundamental problems are essentially psychological. Values and human needs are largely mental. It must be said, however, that psychology is least well developed in the fields where it would be most helpful to the historian and to the economist. Last of all, the relations of psychology to philosophy are very numerous and are those of mutual helpfulness. Psychology was the last of the sciences to separate from philosophy, the parent of all of the sciences, and the bond is still very close. The history of psychology is still very largely a part of the history of philosophy. The results of psychology constitute much of the foundation of philosophy, and on the other hand philosophy supplies the psychologist with

general principles and sets very many of his problems for him.

Practical Applications. — Of the immediately practical subjects, education has probably made the largest demands upon the results of our science. Learning and teaching are both psychological operations. When any real attempt to understand either is made, education becomes an application of psychology. This is more and more appreciated in the modern schools, and in them psychology and education are coming closer and closer together. The psychologist is paying more attention to the problems of the educator, and the modern educational theorists are making more use of the results of psychological investigations. The late war gave an opportunity to show that psychology had widespread possibilities of application in the most diverse fields. Most of the men who were selected by the draft were given mental tests by the psychologists and the results were used in assigning each individual to his task. Those of little intelligence were put in the labor battalions. Officers and men for the flying service and other special duties were chosen from among those who stood high in the tests. The same methods have been applied by many large industries for the selection of their employees. They find that it is quite as important and almost as easy to measure the capacity of their workers as it is to test the strength of the materials used.

Elaborate organizations have been developed in many of the great cities to give psychological examinations to criminals. Working in harmony with physicians who specialise in mental diseases, many criminals are given examinations and the final disposition that is made of the case depends upon the results of the examination. Special use of this

information is made in dealing with children. An important application of psychology has been made by the advertiser. The psychologist has developed many laws that can be applied to advertising practice and the advertiser has adopted psychological methods of experimentation to determine the best forms of advertising material and the most economical use to make of his space. Many industries make use of psychological tests in selecting employees or in determining advancement. This incomplete list of the relations of psychology may suffice to indicate how closely psychology is bound up with other fields of human knowledge. Any science that tells us anything of the nature of the physical universe or of the nature of the living organism will throw some light upon the problems of psychology. On the other hand, any science that deals in any way with human conduct, or that is dependent in any way upon human capacity (and what science is not?), can draw with profit upon the results of psychology. Either as creditors or debtors, all the sciences stand in some relation to psychology.

Divisions of Psychology. — Each of the sciences that furnish material for psychology has given rise to a different sort of psychology, or at least to a different name for a psychological work. Psychophysics grew out of an attempt by Fechner to determine the quantitative relations between the physical stimulus and the intensity of the mental state. Physiological psychology is the name Wundt gave to his work, that had for its primary object the explanation of the relation between mental states and the bodily organism. Each of these treatments has grown beyond its original scope to cover the entire field of psychology. The name now indicates nothing more than the attitude that is taken

toward the subject. Other branches of the subject are named from the phase of behaviour that is discussed. Genetic psychology treats of the development of behaviour. The behaviour of animals has given rise to a flourishing science which in the last few years has made much progress. Child study has made numerous contributions to the more theoretical problems. Each has thrown some light upon the nature of adult human behaviour, as well as collected many facts in its own field. Abnormal psychology, the study of defective and insane individuals, has also been a rich field for the psychologist and has given many important results. Each of these partial sciences will be considered by us only so far as it throws light on the behaviour of the adult normal man.

Summary. — Our problem is to understand behaviour, and to investigate the laws of human experience as the immediate antecedent and condition of behaviour. To understand either experience or behaviour it is necessary to know something of the nervous system. All knowledge of the world comes to us through the nervous system and all expressions of consciousness in action are rendered possible by the nervous system. This is not psychology but is a necessary prerequisite for psychology. The psychological inquiry proper begins with a determination of the simplest laws of behaviour and the fundamental aspects of knowing; it involves a study of how these simplest laws can be traced in the more complicated activities. The various partial problems will be taken up in the order named: first, (a brief statement of the facts of nervous physiology that have a bearing upon psychology;) second, (an analysis of the facts of consciousness and behaviour to discover the elementary components) and third, (a study of

the more complicated activities in the light of these simplest forms.

QUESTIONS

1. What do you mean by mind? by consciousness? by experience?

2. Which of the above processes are you directly aware of in yourself, — if you are aware of any one of them?

3. What do you regard as evidences of mind (*a*) in an animal, (*b*) in another man, (*c*) in yourself?

4. Describe cases in which you might have behaviour without consciousness in yourself; in another.

5. What is a science? How can we develop a science of behaviour? Can we have a science of mind? of consciousness?

6. How does introspection differ from observation?

7. What objection has been raised to the use of introspection? Would the same objection hold to observation as well? How can the objection be met?

8. Describe a psychological experiment. Give an illustration for introspection; another for observation.

9. How would psychological laws apply to making a golf stroke? to learning this lesson? to holding your temper when provoked?

10. State one psychological problem that might be solved by a test.

11. Give one psychological question that could be answered by statistics.

12. How does a knowledge of the action of the nervous system help in the answering of psychological questions? What more would be involved in psychology?

13. How would knowledge of psychology help a judge? a physician? a teacher?

14. Enumerate some of the more important branches of psychology. What gives the name to the branch in each case?

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CHAPTER II

THE NERVOUS SYSTEM

WE must deal extensively with the nervous system if we are to understand man's thought and action. The nervous system is composed of a tissue rather soft in consistency, gray in colour in certain parts, and white in others, of about the specific gravity of water. We distinguish a more central and a more peripheral portion. The central portion is found in the upper part of the skull, — this is the brain; and in the spinal column, the spinal cord (see Fig. 7). From these central portions fibers or nerves extend to all of the muscles of the body and to each of the sense organs. Since these are in the outer portion of the body and extend to its periphery, they are known as the peripheral nerves. In addition to the brain and cord which constitute the main portions of the nervous system, there are small knots of nervous tissue scattered through the head and trunk, which connect with the more automatically controlled organs: muscles of the iris in the eye, and the larger visceral organs. These together are known as the autonomic nervous system.

The Evidence for a Connection between Behaviour and the Nervous System. — While all now believe that both behaviour and thought are closely dependent upon the action of the nervous system, there is no direct evidence of this relation. You are not directly aware that your brain acts as you speak. It was only very gradually that any definite knowledge of the nervous system developed,

larger nervous system - more intelligence
more complicated structure N.B. higher intelligence.
injuries to nervous system produce disturbance of behaviour.

and even more slowly that men became aware of how action and thought depended on nervous activity. We are now convinced of the connection because, first, the larger the nervous system in a species or, with exceptions, in an individual, the more intelligent the animal. Secondly, the more complicated the structure of the nervous system, the higher is the intelligence of the animal. Thirdly, injuries to the nervous system produce disturbances of behaviour and the nature of the disturbance is closely parallel to the part of the brain that is injured.

The direct ratio between the size of the brain in a species and the intelligence of the species shows two exceptions. Very large animals may have an absolutely larger brain than a more intelligent smaller animal. An elephant has a larger brain than man, and we are not willing to grant that he is more intelligent. A better measure is the ratio between body weight and brain weight. If we accept this, however, we find an exception to its validity in the fact that very small animals have a greater proportion of brain to body than more intelligent larger animals, a humming bird has relatively more brain than a man. Apparently a certain minimum absolute amount of brain is essential no matter how small the body. (On the whole, however, the ratio of brain weight to body weight gives a reliable index of the capacity of the animal.) Note

Between individual men the intelligence of the individual varies on the average with his brain weight. Take one hundred intelligent men and compare the average weight of their brains with the brain weights of one hundred stupid men and the intelligent men will show a marked advantage. Records of brain weights kept at the Cleveland morgue of men whose bodies were not claimed showed that during

ordinary times a brain was seldom found that weighed more than 1500 grams, — roughly three pints of brain is the normal allowance. When times were hard individuals with heavier brains began to come in. This was interpreted to mean that in ordinary times only the unintelligent were found in the class that could not keep afloat. When industrial conditions were bad, the more capable also were found among life's failures.[1] It should be said that there are individual exceptions in the relation of brain weight to intelligence. Liebig, the famous chemist, for example, had a brain that weighed only 1352 grams, while some idiots have large brains. On the average the relation holds.

Complexity of Nervous System Grows with Complexity of Behaviour. — The animals which have very simple responses also have either no separate nervous system or a very simple one. In the single-celled animals the same protoplasm that is involved in nutrition or movement also receives the stimulus and contracts. The protoplasm is alike everywhere, and essential operations are performed by any portion. The movements are correspondingly simple and the animal poorly adjusted to its environment. As we go higher in the animal scale we find the rudiments of a nervous system, but the nerve-cells are simple and the connections relatively scant. Behaviour is more adequate as the nervous system is better developed. In the lower vertebrates, a reptile for example, the nervous system is larger, the parts are more highly developed, and the connections between the elements are more numerous. The movements are also more complicated, and they are more

[1] T. Wingate Todd: "A Liter and a Half of Brains." *Science*, N. S. 1927, 66, p. 122.

Mind is private view
Behaviour is public view.

closely adapted to the environment. The animal is better equipped to live and to act. The increase in complexity of a single element or neurone from the cortex of the brain as animals go higher in the scale can be seen in the upper part of Figure 1.

FIG. 1. — Shows the development of pyramidal cells from the cerebrum of vertebrates. (*A–D*) neurones from an ascending series of vertebrates, (*a-e*) the stages in the development of cells in man. (*A*) frog; (*B*) lizard; (*C*) rat; (*D*) man. (*a*) neuroblast without dendrites; (*b*) commencing dendrites; (*c*) dendrites further developed; (*d*) first appearance of collaterals; (*e*) further development of collaterals and dendrites. (From Howell, *Text-book of Physiology*, after Ramon y Cajal.)

The climax of evolution, both in behaviour and in the structure and connections of the nervous system, is found in man. (In short, mind or behaviour develops in the same

?

Note degree as the nervous system, whether we measure the development of the nervous system by the character of the nerve unit, by the nature of the connection between nerve units, or, with few exceptions, by the ratio of nervous tissue to body weight.

Defects of Brain and Mental Defects. — The evidence from pathology for the close relation of mind and body is even more striking. A slight injury to the head may destroy consciousness. Injury to certain small areas of the brain gives rise to paralyses of small groups of muscles, to other areas causes the loss of some sense. Injury to almost any part of the nervous system impairs some capacity in some degree. Conversely if behaviour or consciousness is affected, some change in the nervous system is usually found. These two facts taken in connection with what we know of physiology, and what can be seen directly of the action of nerve in connection with muscle in the lower organisms, suffice to make indisputable the very intimate relation between mind and brain.

Development of the Nervous System. — It is perhaps easiest to understand the nervous system if we consider it in connection with the development of the animal organism from the lowest forms. All higher organisms can be regarded as developed from the simplest of unicellular forms. Note The amœba may be regarded as the type of the original simplest animal. The amœba is a single cell. This cell is at once nervous system and muscle, mouth and stomach. When it moves, the cell contracts or expands or changes its form as a whole. When it is stimulated, the impression is received by part of the cell, and the same and neighboring parts contract. When the stimulus is a food particle, it induces a movement of the cell or part of it

toward the particle and about it until the particle is entirely surrounded. Then the same protoplasm that received the stimulus apparently acts as a digestive organ to assimilate the morsel. The original cell is thus possessed in some degree of the capacities of all parts of the human or higher organism. Note

The development of the higher organisms may be regarded as due to the coming together of many of these simplest cells to form a single whole or colony. Whether or not separate cells ever did combine in this way is a matter of indifference. It at least illustrates the nature of the relation of simple cells to the more complicated organism. The different cells take on different functions and, in many cases, different forms. No matter how changed, each cell of the body is regarded as a separate organism that has lost something of its individuality, but is nevertheless descended directly from the independent amœba-like prototype. The bone cells perhaps are most removed from the original; the white corpuscles of the blood have changed hardly at all. Next to the white blood corpuscles the nerve-cells probably have been least altered from the original type. Except for its dependence upon the other members of the colony for its food, and for the fact that the other cells serve to give it form, a nerve-cell is still independent. The function of the nerve-cells in the colony is to make possible the coördination of the activities of the cells. When one cell is stimulated, a group of cells at a distance, constituting a muscle, may respond. The nerve-cells compel the parts to act together and make the organism a unit for action rather than a mere mass of separate entities. N. B

Behaviour as the Effect of the Nervous System. — The behaviour of man depends upon the working together of

these elements. When a man flicks at a fly, the sight of the fly starts the action. Certain cones in the eye are stimulated and this starts the chemical process we call a nerve impulse on its way to the brain. In the brain it passes across to motor neurones which incite the muscles of the arm to contract and so cause the movement. When one sneezes, an irritation of the membrane of the nose excites a similar impulse that goes to the lower parts of the brain, and so over motor nerves to muscles of the chest. They contract and the blast of air that follows removes the source of irritation. In every action numerous elements of the nervous system coöperate. Every act starts with the arousal of a chemical process in some nerve element on the surface of the body and is completed by the spreading of this process to a group of muscles. Such a simple act we know as a reflex. We can understand such an act if we know what the elements of the nervous system are like, how they are put together, and how they act. We shall consider first the nature of elements or neurones, secondly what a nerve impulse is, and how the neurones work together to offer paths for the transmission of impulses from one part to another. To follow the paths we must know the main structures of the nervous system.

The Elements of the Nervous System. — We may most adequately represent the nervous system as a colony of some eleven thousand million of these amœba-like cells crowded together for the most part within the bony walls of the skull and spinal column. The unit of the nervous system is called a neurone. The central cells have prolongations that extend to all parts of the body, to each sense-organ and to every muscle and gland. These prolongations also form paths of connections between the

neurones within the same parts of the nervous system and connect the different parts. Neurones are named from their functions as sensory, motor, and associatory. The sensory neurones extend inward from a sense-organ, the

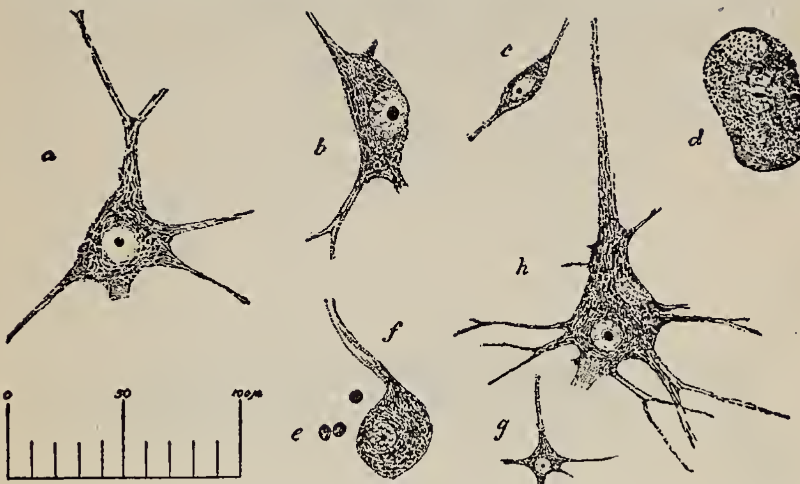


FIG. 2. — A group of human nerve-cells drawn to the same scale. (*a*) small cell from ventral horn of the cord; (*b*) cell from Clarke's column, thoracic cord; (*c*) small nerve-cell from tip of dorsal horn, thoracic cord; (*d*) spinal ganglion cell, cervical root; (*e*) three granules from cerebellum; (*f*) Purkinje cell from cerebellum; (*g*) small pyramidal cell from second layer of central gyri of cortex; (*h*) giant pyramidal cell from the same region. (*d*) and (*f*) do not show processes. (From Donaldson, in the *American Text-book of Physiology*, after Adolf Meyer.)

motor extend outwards to a muscle, and the associatory provide a path between sensory and motor neurones. Their form does not necessarily vary with their function. Dec. 9

The Neurone and Its Parts. — The neurone consists of a cell body and two sorts of extensions or processes, the axone or axis cylinder, and the dendrites. The cell body is a mass of gray colour of varying form, with a nucleus in the approximate center. It corresponds to the body of the

mass of gray matter within the brain
or spinal cord.

amœba. From it the processes grow as can be seen in the lower part of Figure 1. The axone is a long hairlike extension that may reach more than half the length of the body, as from the lower part of the cord to the muscles of the lower leg. The axone terminates, except when it ends in a muscle, by splitting into short branches that constitute the end-brush. The dendrite is usually composed of a number of relatively short branches, and may look much like an end-brush. Dendrites differ from axones primarily in the function of each. Dendrites carry impulses to the cell bodies; the axones carry them away from the cell bodies. The axone end-brush of one cell is ordinarily in contact with, or very near, the dendrites of other cells. The points of contact are called the synapses. The form of the neurone varies greatly, as can be seen in Figure 3. In some cases the cell body is approximately round and relatively smooth. In other cases it is more spindle-shaped, in others again the surface is much broken by the processes. In certain parts of the cortex the cells are almost pyramidal in their general shape, with processes at each of the angles. In the spinal ganglia, the cells that receive and transmit the nerve current from the skin and muscles, seem to have but one process near the cell body. A short distance from the cell body, however, this single fiber divides into two. One branch that corresponds to the ordinary dendrite grows out to the skin, the other that corresponds to the axone extends into the cord and then either across to connect with motor

D to C.B.
to A

Note

FIG. 3.—A T-shaped cell from a spinal ganglion.

T-shaped cell is one which has a cell body with apparently only one process near the cell body.

neurones or up towards the brain. They are known as the 'T'-shaped cells. All of these forms are to be regarded as departures from the type. But the character of the cell has no demonstrable relation to the function. The number of dendrites and the number of branches of the axone determine the number of connections that the cell may make; the form of the cell depends upon the number and position of the processes, but so far as is known that is the only relation that holds between form and function.

FIG. 4.—Longitudinal and transverse sections of medullated nerve fiber from the sciatic nerve of frog. The myelin sheath is shown in black, the central protoplasm shows its fibrous structure. (From Barker, after Biedermann.)

The Life of the Neurone. — The neurone is a vital unit. The processes receive nourishment only from the cell body, and when cut off from the cell body, they die. The substance or protoplasm of the cell body is continuous with the protoplasm of the processes. Two sheaths surround most of the axones, an inner or myelin sheath, and an outer, the neurilemma. The inner sheath is found in all except a few fibers in the higher centers, the second is present outside of the central nervous system. In the sympathetic system the outer sheath is usually the immediate covering of the protoplasm. The myelin sheath seems to have some importance for the function of the neurone, but just

what has not been made out. The nucleus of the cell stands in some vital relation to the action of the cell. In fatigue the nucleus has been shown to become smaller and irregular in outline. Its exact function, however, has not been determined.

Transmission of the Impulse within the Neurone. — We speak of the action of the nervous system as due to the running back and forth within it of nerve currents. The obvious next question is what actually moves along the nerve during the action. Certain facts have been determined experimentally which are taken into consideration in the theoretical explanation. (1) The impulse moves along the nerve at the rate of about 100–123 meters per second. This is too slow for an electric current which was once thought to be the cause of the nerve action. (2) The action of the nerve is accompanied by electric phenomena. When a nerve is stimulated, a weak electric current will flow from the point stimulated to neighbouring parts. There is a negative charge that moves along the nerve at a rate equal to the propagation of the nerve impulse. (3) As the cell acts, certain products of chemical decomposition can be detected which show that chemical action is going on. A recent theory is that the impulse may start in a chemical reaction. This arouses an electrical process which extends a short distance; then it excites a new chemical change, which in turn initiates an electrical process. And so it is thought that there is a continuous alternation from chemical to electrical response and that these together constitute the nervous impulse. With the newer physico-chemical theories that reduce all chemical changes to interchanges of electric charges, the chemical and electric phenomena would obviously be inseparable.

sensory neurones extend inward from a sense-organ

motor neurones extend outward to a muscle

Electric Current and Nerve Current. — Lucas and Adrian have shown that the strength of the single electric current that arises when the nerve is stimulated is always the same no matter whether the stimulus is weak or strong. This is called the 'all or none law' of nervous reaction. Any stimulation of the nerve produces not one electric response but a series of responses. If the stimulus be weak there will be relatively few electric impulses, while a stronger stimulus produces a greater number and they will succeed each other much more quickly than they do in case the stimulus is weak.

Conduction of Reflexes. — In the separate nerve an impulse seems to run equally well in either direction. In the actual nervous system, however, conduction is always from a sense-organ to a muscle, and in the neurone from a dendrite to an axone. This is probably due primarily to the fact that an impulse passes in one direction only at the point where axone and dendrite come together, the synapse. The dendrite and axone come into close contact and the nerve impulse will pass from one to the other. However it is brought about, a nerve impulse can cross a synapse only from the axone to the dendrite and not in the reverse direction. The synapse acts as if it were a valve that could open only in one direction. The synapse is really the controlling factor in nervous conduction. It is therefore the connections of a neurone that determine in which direction an impulse shall pass and also whether it shall be sensory or motor. If a neurone has its dendrite end towards a sense-organ, it can only conduct away from the sense-organ and is called sensory. It must also conduct towards the central nervous system, and so is known as an afferent neurone or one that leads towards the center. If its dendrites

dendrites carry impulses to the cell bodies

axones carry them away from the cell bodies

d → sense organ (away)

extend towards the center and its axones towards the muscle, it leads away from the center and so is efferent or motor.

The Growth of the Nervous System. — The nervous system is, we have seen, made up of a vast number of neurones with dendrites that extend to receive impressions from sense-organs and axones and transmit them to muscles. If we are to understand the action of the nervous system we must know something of the way the nerve elements are combined in the actual nervous system. In the adult the nervous system is a series of structures confined within the skull and extending down the spine, so far as the cell bodies are concerned, while the nerves are processes of the neurones that grow out to the skin and other sense-organs and to muscles in all parts of the body. The architecture of the different parts can be understood most clearly from a study of the development of the system. In the early stages of the embryo the central nervous system is but a groove in the outer layer of the mass. This groove gradually becomes deeper, and the tops of the sides approach until they grow together to form a tube. The different parts of the entire nervous system grow from different parts of the wall of this tube. The original hollow persists to the adult stage and is modified by the changes in the shape of the wall. The brain develops from the anterior, the cord from the posterior part of the tube.

The anterior portion of the tube is first constricted in two places to form three small swellings which are known as vesicles; later the first or more anterior of these and the third or posterior each divides into two to make five in all. The hemispheres of the cerebrum are outgrowths from the sides of the first vesicle. They can be seen in a very early stage in Figure 5, which shows the five-vesicle stage. Later

Note

these lateral extensions grow up and back until they cover the central structures. In the adult they constitute the greater part of the whole brain. The structures of the brain stem develop from the four lower vesicles by the thickening of the walls. The spinal cord evolves by a similar thickening of walls by division of the original cells from the remaining longer portion of the original tube. The connections of parts retain in the adult many traces of the earlier stages. A study of the growth has thrown much light upon relations that were not clear before.

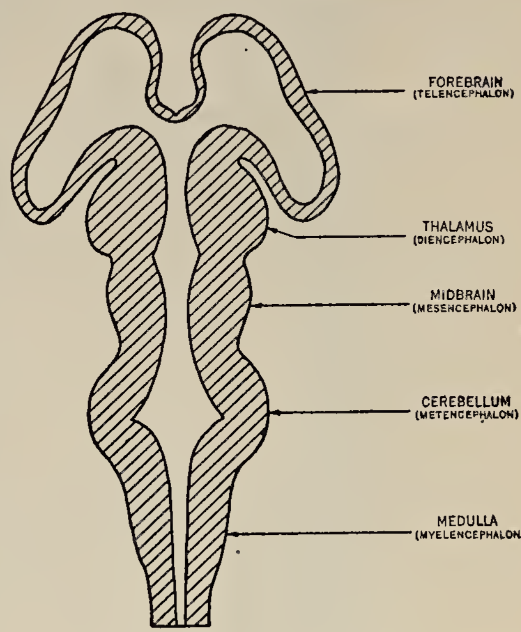


Fig. 5. — A schematic representation of an early stage in the development of the brain and brain stem. At the top can be seen the developing cerebral hemispheres. At the right is given the names of the original part and the more important structures which develop from each.

The Divisions of the Nervous System. — The more important parts of the adult nervous system can be made out in general from Figure 6. At the top within the skull is the brain, a popular term applied to the cerebrum. The cerebrum is an outgrowth of the anterior vesicles. The cerebrum is made up of two hemispheres which grow out from each side of the vesicle, and then extend upward and back until they meet above the original brain tube. The

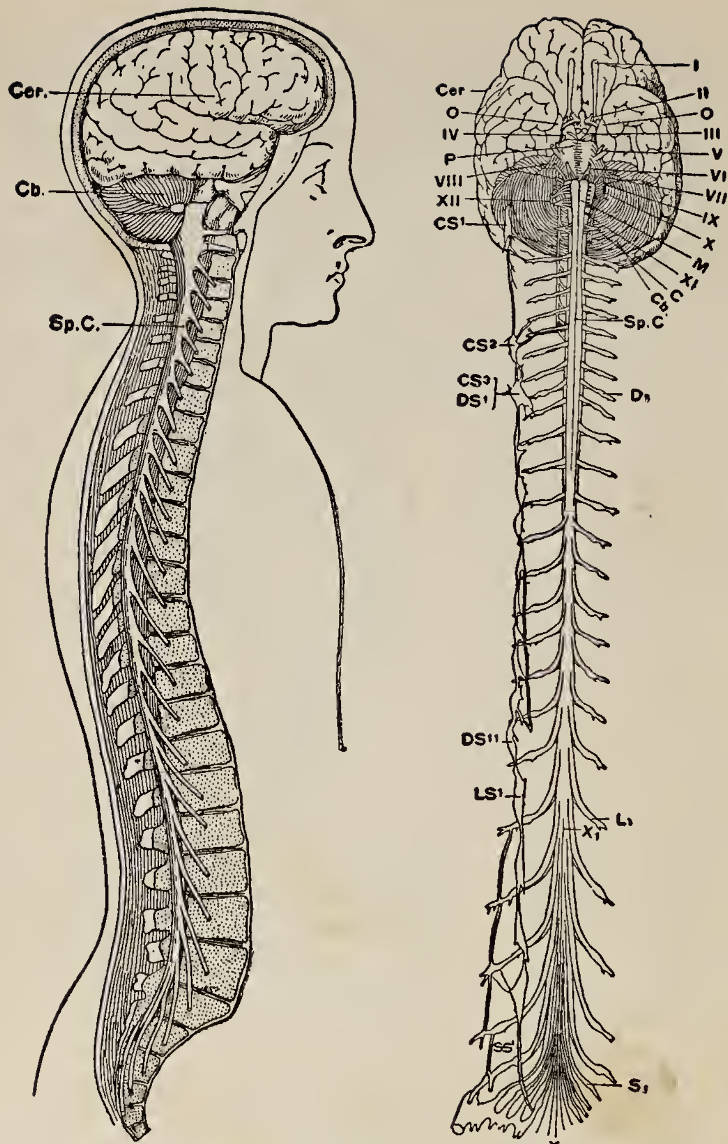


Fig. 6. — Shows the nervous system as a whole. The figure on the left represents the relation of the nervous system to the body as a whole, that on the right the nervous system exposed and seen from the front. (*Cer.*) the cerebrum; (*Cb.*) the cerebellum; (*Sp. C.*) the spinal cord; (*P*) the pons; (*M*) the medulla. The other letters in the right-hand figure designate nerve trunks going to the autonomic nervous system and the body as a whole. (From Angell, *Psychology*.)

median fissure is space between two hemispheres of cerebrum

space between them is known as the median fissure. When they first develop, each has a thickening in front and behind which make the whole at one stage look much like a bean. The two ends gradually grow towards each other and with growth of the skull are pressed together until only a deep fissure separates them. This is the Sylvian fissure, which runs up and back from the lower front surface of each hemisphere and constitutes a prominent land mark.

The other vesicles also develop by thickening of the walls. The tween-brain develops into the thalamus on the sides of the original groove. The mid-brain next behind develops from its roof the *corpora quadrigemina*, which are reflex centers for the eyes and ears. The hind-brain still farther back undergoes a great increase in the thickness of the back wall which becomes the cerebellum, next to the cerebrum the largest organ in the brain. The anterior wall of the hind-brain thickens considerably to form the pons, largely a mass of fibers that connect the two halves of the cerebellum. The after-brain, the most posterior of the vesicles, develops into the medulla, which is but slightly larger than the cord, just below it.

White Matter and Gray Matter. — Each of the parts of the nervous system when cut across shows some tissue of a reddish gray colour, the gray matter, and other tissues of glistening white, the white matter. Masses of gray matter are called ganglia (singular, ganglion) when outside the central nervous system; when within it, they are called nuclei. The gray matter is made up of cell bodies, the white matter of nerve fibers. In the cord the gray matter is in the center, where it constitutes a butterfly-shaped central core. The butterfly shape is well marked in the sections, as can be seen in Figure 7. In the cerebrum

neurone extends inward to a sense organ.

and the cerebellum the cell bodies are for the most part upon the cortex (bark), the outermost layer; the white connecting parts are within and below. In the medulla and brain stem, no law for the distribution of white and gray matter can be stated in a few words. Strands of fibers are interspersed with masses of cell bodies, — here one, there the other, is on the surface.

The Reflex Act as the Unit of Function. — If the neurone is the structural unit, from which the nervous system is constructed, the reflex is the functional unit. All action of the nervous system can be said to be built up out of reflexes. A reflex is an immediate unlearned response to stimulation. Winking the eye when a flying stick comes near is a reflex. Drawing back the hand when it is burned is another. The reflex is caused by the passage of a nerve impulse from a sense organ to a muscle. It depends upon the immediate actions of the nerve itself and cannot be controlled by consciousness. You cannot prevent the wink by trying, nor can you prevent the withdrawal of the hand when the burn is sudden. A reflex always is caused by the stimulation of a sense-organ and through that of a sensory neurone. This in turn excites a motor neurone, and through that produces the contraction of a muscle or muscle group. The simplest reflex may involve only two neurones, the sensory and the motor. In the more complex several other associating neurones may intervene, but these beginning and end structures must always be present.

The problem of action from the side of nerve physiology is one of determining the paths of connection between the sensory and motor neurones. The course of transmission from neurone to neurone is determined by the openness of the paths. These connections are in part fully formed in

a mass of gray matter within the brain or spinal cord.

the organism at birth, in part they are acquired through the activities of the animal during life. Of these paths of connection we may recognize three levels: first, the direct connections of the cord; second, the paths through the brain stem, the medulla, and general mid-brain region; and third, the more indirect and complicated lines of connection in the cerebral cortex. Each is to be looked upon as a path between sense-organ and muscle. They are different ways by which the sensory impression may be transmitted to the muscle: they are different primarily in the directness with which the transfer is made; the higher paths permit more connections and make possible the coöperation of a greater number of sensory impulses in the control of movement. here

The Action of the Cord. — In the cord sensory currents from the skin and from internal structures are carried across to the muscles of limbs and trunk. Through it appropriate responses are made to stimuli of various sorts on the skin. Drawing back the hand when burned is primarily due to the nervous connections in the cord. The simplest reflexes of the cord involve two neurones only. The end-organ in the skin is connected with the dendrite of the T-shaped cell in the spinal ganglion, the axone of that cell extends into the butterfly-like section of gray matter in the cord, and the end-brush comes in contact with the dendrite of a cell on the anterior side of the cord. This motor cell in its turn sends out an axis-cylinder to a muscle. The chemical change induced by the physical stimulus travels to the cell body, thence to the end-brush, where it excites an impulse in the efferent neurone that travels down to the muscle. The impulse is transferred at that point from nerve to muscle and excites the chemical change involved in the muscular contraction. The diagram shows that the spinal

cord consists of a mass of white fibers which surround a core of gray matter. In the latter are the cell bodies of the motor nerves, and the associating or connecting neurones. The surrounding white matter is divided by the extensions or horns of the gray matter into four parts or columns. Of these the posterior is made up of axones from the cells in the spinal ganglia, is sensory in function, while the others are both sensory and motor, outgrowths of cell bodies in the central gray or from cell bodies in the cortex or brain stem.

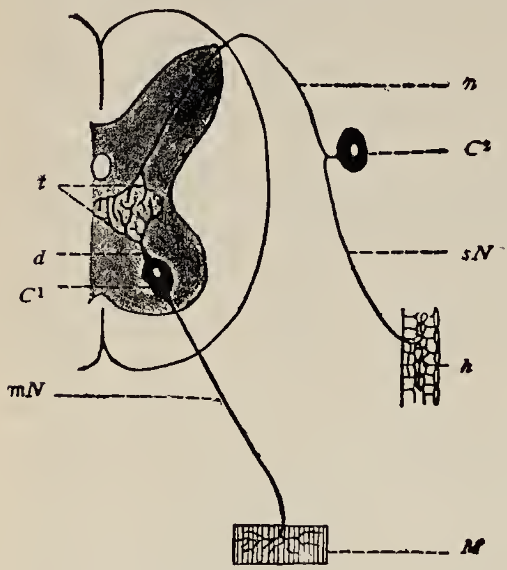


FIG. 7. — Shows the simple reflex connection through the cord. (C^2) T-shaped cell in the spinal ganglion; (sN) long dendrite or teledendrion to (h), sense ending in skin, impulse passes over axone (n) to synapse (t) and dendrite (d) to (C^1), motor-cell in the anterior horn, and thence over the axone (mN) to muscle (M).

The Paths in the Cord. — If the central gray may be regarded as the transferring station, the surrounding white constitutes the transmitting paths by which the cortex and higher centers in general are connected with the world outside. The sensory tracts bring nerve impulses in from the periphery and transmit them to the brain. The motor tracts serve, on the other hand, to connect the upper centers with motor cells in the cord, and thus with the muscles of the lower parts of the body. Not only do these outer fiber

layers connect the upper portion of the nervous system with sense-organ and muscle, but they also connect the different levels of the cord with each other. A sensory impulse excites both muscles that have their cells at the same level in the cord, and also groups of muscles at different levels above and below. If we return to consider the simple reflexes, we find that the sensory stimulus may spread not merely to the single motor neurone or group of motor neurones at the same level, but it may make connections with neurones that lie higher and lower in the cord. It may also extend to neurones lying in the opposite side of the cord and produce movements of members on the other side of the body. These reflexes may be readily demonstrated in a frog. If one destroy the brain of a frog or, with a knife, cut the cord off from the upper nervous system, it will be seen that all of these reflexes may still be called out by stimuli. If a bit of paper moistened with acid be placed upon the left foot of a frog, the foot will be drawn up. If now the foot be held so that it cannot be moved, it will be found that the other is brought over to remove the stimulus. If this is not successful, the muscles of the forelegs and trunk will contract and the contractions will continue until the stimulus is removed or the muscles are fatigued. The first movement (of the left leg) is due to the transfer of the stimulus to the motor cell, or cells, on the same side of the cord. When the foot is held and the stimulus grows strong enough, the impulse is transmitted to the group of neurones on the opposite side of the cord, and muscles of the right leg are contracted. When the excitation becomes still stronger, the discharge spreads to neurones higher up, and the muscles of the trunk and forelegs are made to contract. Here.

Action of the Synapse. — Since there are evidently many

possible lines of transmission, the question naturally arises, what decides which of the many paths shall be followed? The answer is found in a generally accepted theory that the course of the impulse is determined at the point of connection between neurone and neurone, the synapse. The end-brush of the receiving neurone is in contact with the dendrites of several other neurones. Each of these points of contact or synapses has a different resistance. The path to muscles of the same leg is most permeable; next in

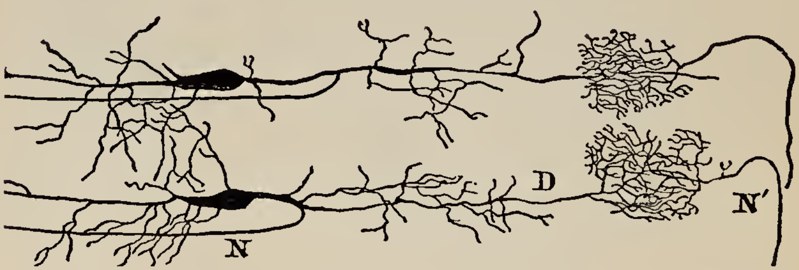


FIG. 8. — A synapse from the optic lobe of a chick. (N′) axone of a distant cell-body connects through its end-brush with (D) the dendrite of the second cell. (N) is axone of second cell. (From *American Text-book of Physiology*, after Van Gehuchten.)

degree of permeability are the synapses to dendrites of the motor neurones that control the muscles of the other leg, while the synapses that connect with the muscles of the upper trunk open with still greater difficulty. The lines of discharge depend primarily upon the openness of the synapses. In these lowest reflexes the ease of transmission varies with the character of the synapses as they are determined in the individual at birth, and thus the responses are prepared in advance of any experience. When the sensory excitation is weak, only the easiest paths are followed. As the impulse becomes stronger, more and more difficult synapses will be crossed, and new muscles will act.

The Transmission between Cord and Brain. — The nerve impulses which enter the cord are also transmitted to the brain stem and cortex. There they may arouse movements in more widely distributed muscles, and in the cortex they in some way modify consciousness. The cortex also sends the impulses to voluntary action to the cord and through it to the muscles. The main paths from the cord to the cortex and from the cortex to the cord may be traced in Figure 9. Sensations from the muscles are carried to the cortex by the intermediation of three neurones. The first is the T-shaped cell in the spinal ganglion (D). Its modified dendrite connects

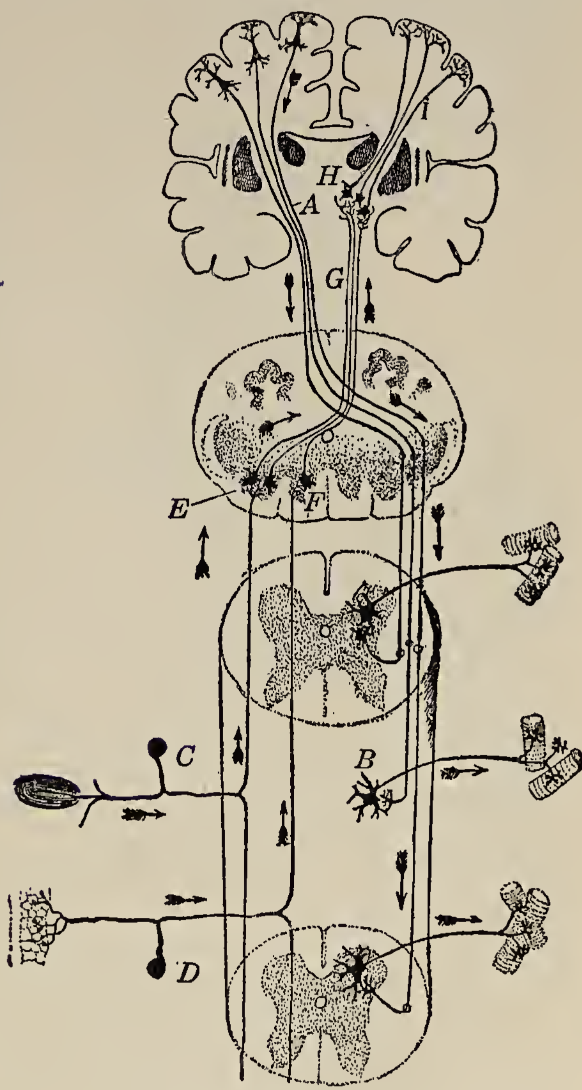


FIG. 9. — Shows the paths from cord to cortex and from cortex to the cord.

with a sense-organ in the body of the muscle, its axone passes up the posterior portion of the cord to make connection with a second neurone (*E*) in the medulla. The axone of this second neurone extends to the thalamus, where it forms a synapse with a third neurone (*H*). The axone of this neurone transmits the impression to the cortex. Sense impressions from the skin go from the T-shaped cell to a second neurone in the central gray of the cord, whose axones ascend directly to the thalamus at (*H*), and thence by a third neurone to the cortex. When the hand is moved in a voluntary act, the impulse is transmitted from the motor pyramidal cell in the cortex along the axones, shown at (*A*) in Figure 9, to cells in the anterior horns of the cord (*B*). The axones of these cells go out directly to the muscles. Three neurones are required to carry sensory impulses from muscle or skin to the cortex, while but two are necessary to transmit the voluntary motor impulse from the cortex to the muscle.

The Brain Stem. — The portion of the nervous system between the upper part of the cord and the cerebrum, is known generally as the brain stem. Structurally it is composed of fibers which pass through on the way from the cord to the cerebrum and from the cerebrum to the cord, and of nuclei which receive nerves from the sense-organs or send fibers out to muscle groups. The brain stem has two definite types of functions. Simplest are the reflexes. These correspond very closely to similar functions in the cord. The smaller nuclei are points where connections may be made between sense-organs of the head and muscles of the head. Winking the eye at a bright light, or when the eye becomes dry, is a reflex of this type. The bright light sends a nerve current over the optic nerve to the mid-brain, and

from that to a motor nucleus and over a motor nerve to the muscles of the eyelid, which produces the contraction of the wink. In addition to these simple reflexes they have the function of adjusting larger groups of muscles to stimulations from several sense-organs and so adapting the individual to a wider environment. In this the functions of the brain stem gradually merge with those of the brain proper.

Racial Responses and Learned Responses. — The relative proportions of different parts of the brain and brain stem vary with the stage of evolution. In the reptiles, birds, and lower mammals, the tween-brain and lower portions of the cerebrum are relatively well developed and the cortex and upper regions of the cerebrum as a whole are small. In man and the higher mammals, these portions of the cerebrum are large. (Corresponding to this relative size of the organs, we find in the lower animals a predominance of the relatively stereotyped and unvarying responses while in man these are overshadowed by the results of learning.) Note

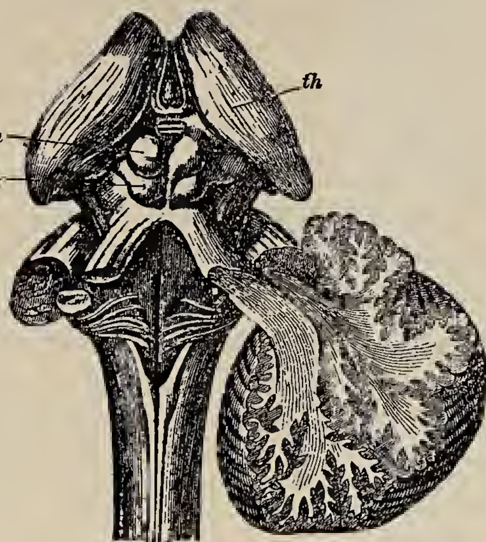


FIG. 10. — The brain stem seen from the posterior side. (*th*) is the thalamus, (*n*) the anterior, (*t*) the posterior, corpora quadrigemina. The large mass at the lower right is the cerebellum, drawn to one side and shown in section. (From Wundt.)

Cerebellum as the Balancing Organ. — Two slightly

afferent - conducting inwards or towards.

different types of coördinations are made possible by the cerebellum and by the thalamus. The cerebellum is the balancing organ. It receives afferent fibers from the sense-organs in the body of the muscles, from the skin, from the eyes, and from the vestibule of the ear which we know to be stimulated as the head changes its position. From it motor fibers go down the cord to make connections with the motor cells in the anterior horn, which send their axones to the muscles of the legs and trunk, and they also go up to the centers for the eye muscles. The afferent impulses from all of these senses which indicate the position of the body are coördinated by their mutual interaction, and there results a distribution of motor impulses to the different muscles in just the right relative proportion and with the proper timing to keep the body balanced. When the cerebellum is injured, the body makes uncertain swaying movements and the gait becomes irregular. While balancing is an unconscious process and is controlled by the brain stem alone, the voluntary acts of locomotion are also regulated through the cerebellum. This is made possible by nerve tracts which extend from the cortex to the cerebellum on the way to the cord.

Functions of the Thalamus. — The more general responses to stimulations from the environment are to be referred to the action of the thalamus, the highest part of the brain stem. Fibers from each of the sense-organs enter there and make connections with neurones. Some of these neurones merely continue the conduction to the cortex, but others connect with motor nuclei, and make possible the general adjustment of the body. It is probable that many, if not most, of the general responses of reptiles, amphibians, and birds are made through the thalamus, and many of the

1. of or on the surface only. not going deep.

inherited activities of man may involve the thalamus and not the cerebrum. Head, the English neurologist, has reported cases in which a patient suffering from an injury to the thalamus has shown disturbed emotional expression. If one side of the thalamus is injured the patient may express an emotion with one side of the face and not with the other. Similarly a man with a tumor of the thalamus may suffer great pain from slight pressure.

The Cerebral Cortex. — By far the most important division of the nervous system is the cerebrum. In man the cerebrum is the largest of the nervous structures, constituting rather more than half of the total nervous system. It is also the part of the nervous system most closely related to consciousness. In fact, it is very doubtful if any consciousness at all accompanies the action of any other portion of the nervous system. Its structure and functions are very complex, but our guiding principles still suffice to explain its action. It, too, is made up of neurones in various connections, and the neurones act to transfer sensory impressions to motor neurones, and so to excite muscles. The only differences between it and the structures considered above are: (1) that it offers vastly greater possibilities of connection, and (2) that impressions received at an earlier period in the life of the individual play a large part in controlling the course of the later movements. In consequence the processes that intervene between stimulus and response may be regarded as much more important here than they are in any of the reflexes already considered.

Localization of Cortical Functions. — Cell bodies are found for the most part only in the cortex or bark, a superficial layer of the cerebrum only a few millimeters thick.

The inner mass consists of fibers, axones of cell bodies in the cortex or in the brain stem, which serve to connect different parts of the cortex, and the cortex with the muscles and sense-organs. We must distinguish three sorts of areas or regions in the cortex. Certain areas receive the

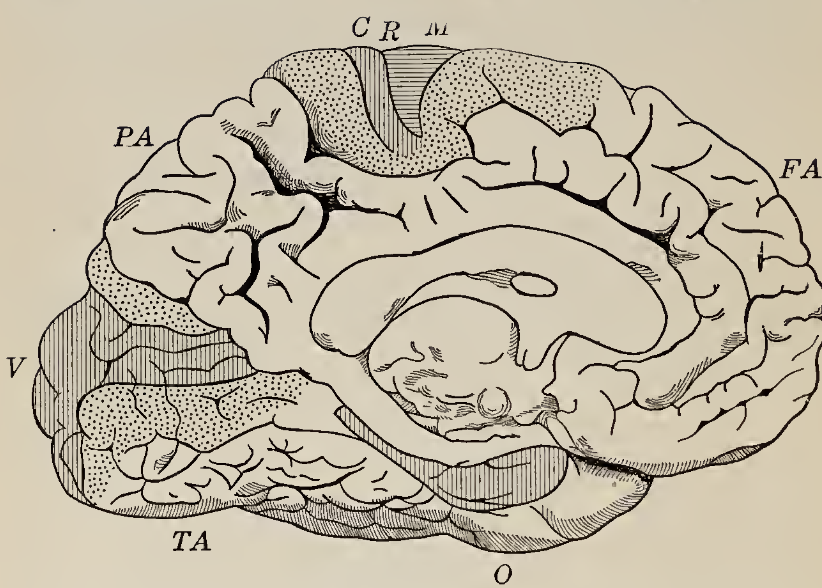
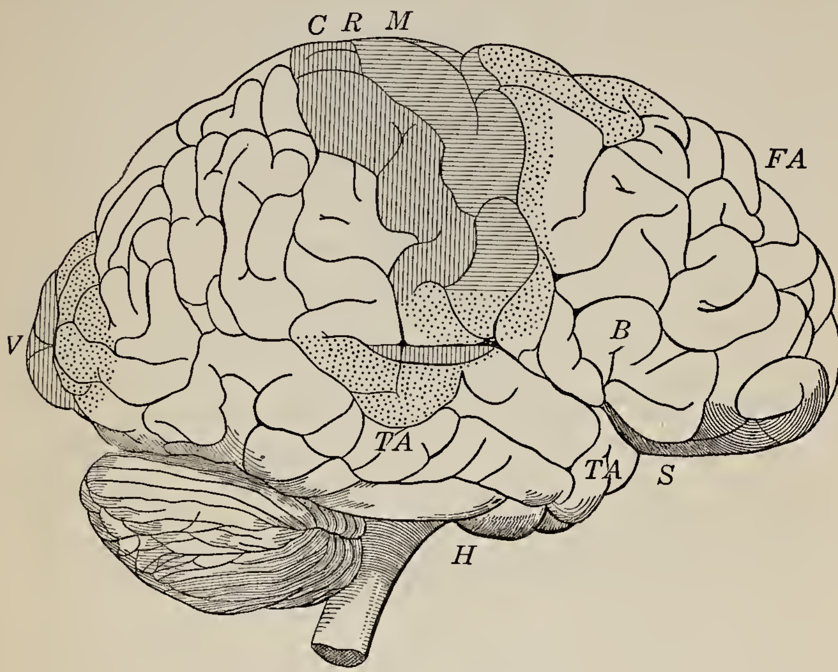


FIG. 11. — Localization of cerebral function. The figure opposite shows the outer surface of the right hemisphere; the one above, the mesial surface of the left hemisphere. In both figures the motor areas are marked by horizontal shading, the sensory by vertical shading, while the associatory areas are unshaded. The doubtful or partially sensory or motor regions are indicated by dots. (*S*) is opposite the fissure of Sylvius; (*R*) above the fissure of Rolando. (*M*) is above the motor region; (*C*) above

impressions from the outside world and are known as the sensory regions. Others send out impulses to the muscles and are known in consequence as the motor regions. The remaining areas serve to connect the sensory and motor and constitute what are known as the association areas. The first two are often grouped together as the projection

areas, since they represent regions of the body in very much the same way that parts of the screen may be said to represent the slide when a picture is thrown upon it by the pro-



the cutaneous and kinæsthetic area. (*V*) indicates the visual region; (*O*) is below the olfactory area. The auditory region is just below the fissure of Sylvius, above (*H*). (*FA*) designates the frontal, (*PA*) parietal, and (*TA*) the temporal association centers. There is some evidence that the dotted regions about the sensory and motor areas are areas in which particular associations are formed with them. (The diagram embodies the results of A. W. Campbell, but has been modified in one or two respects to agree with the results of Flechsig and Cushing.)

jection lantern. The relation between these areas and the sense-organ and muscle is very close.

Localization of Motor Areas. — The position of the motor region is easily demonstrated. If the brain of a man be exposed for an operation and the motor area be stimulated

1. middle line of a body.
retina - layer at back of eyeball sensitive to light.

electrically, some muscle of the body will respond and the same muscle or group of muscles will always respond provided the same region be stimulated in the same degree. The areas that correspond to the different muscles are sufficiently well known to permit the physician to decide what part of the brain is defective in case some group of muscles be paralyzed. The motor area of the brain is shown in Figure 11. It lies just in front of the central fissure, the fissure of Rolando, and extends upward from near the fissure of Sylvius to the median fissure and over to the mesial surface of the hemisphere, the wall of the median fissure. As is generally the case in the upper part of the nervous system, the right brain contains the motor centers for the left half of the body and *vice versa*.

Note.

Sensory Areas. — The sensory areas are larger and each sense has a different area. The visual area is on the median surface of the cerebrum along the calcarine fissure (Fig. 11, *V*), in the occipital lobe. The right half of each retina sends its fibers to the right cortex; the left half of both eyes are represented in the left cortex. The upper half of the retina sends its fibers to the upper wall of the calcarine fissure and the neighbouring portion of the cortex, while the lower halves of the retinas send their fibers to the lower border of the calcarine fissure. The very centers, the foveas, of the two retinas send impressions to the tip of the occipital lobe in both hemispheres. This is proved by the fact that both of these areas must be destroyed if the individual is to be blind in the foveas of both eyes.

Each ear sends its fibers to both hemispheres in the temporal lobe just below the fissure of Sylvius (*T–A*, Fig. 11). The fibers from skin and muscle are received in the areas back of the central fissure (*C*, Fig. 11). Smell is probably

mainly on the mesial surface of the temporal lobe (*O*, Fig. 11). Taste may be near it but the localization is hardly more than conjecture at present. All together it appears certain that each sense-organ sends fibers to a specific relatively small area on the cortex, which may be accepted as the primary center for that sense.

Note

Association Areas. — It will be noticed that after we have marked all of the areas that are known to be connected with sense-organs, and all the areas that serve to arouse contractions of the muscles, the greater part of the cortex is still left. It is now generally believed that the remaining portions of the brain have as their function making cross connections between the sensory and the motor regions, to unite sensory with motor, and sensory with sensory areas. For example, the axone from a cell body in the optic region extends to the intervening association region and there comes into contact with the dendrites of numerous association neurones, each of which in its turn will connect with other sensory or motor neurones, or with other association neurones. Each intervening association neurone will increase the connections that a sensory neurone may make, and these connections increase the number of possible responses that any stimulus may call out.

Action of the Cortex. — The law that all action of the nervous system is a transfer of nerve currents from sensory to motor regions holds for the cortex as well as for the lower parts of the nervous system. The sensory areas receive stimulations from the sense-organs and impulses are transmitted from them over the association areas to the motor areas and from there through the lower nervous system to the muscles. In the simplest cases the motor area may be in the same part of the brain as the sensory. Thus elec-

trical stimulation of the optical area of the brain of an animal may cause eye-movements. More characteristic, however, are the cases in which the motor area is at a considerable distance from the excited sensory area, and can be excited only when the nerve current aroused passes through association areas to reach it. Note

The Cortical Functions in Speech. — Speaking is one of the most important human functions and one that has been much studied in connection with cortical diseases. When a man hears a word and repeats it, the sound excites neurones in the auditory area in the left temporal lobe. This sensory impression may be thought of as extending to neighbouring association centers, where the amplification takes place that corresponds to understanding the word. From that region the nerve currents spread over associating fibers to what is known as the motor speech center in the frontal lobe, a region in front of the regular motor area. This may be regarded as the area from which impulses are distributed in the right intensity to various motor centers that control the many contractions of muscles which must coöperate to pronounce the word. The upper part of the motor region must excite the muscles of the trunk necessary to force air through the throat. The muscles of the larynx, and of the lips and tongue must contract in just the right rhythm, if the word is to be correctly pronounced. The motor speech area makes possible this coöperation. We know that these areas are necessary to speech, because speech becomes defective in case either is injured.

Reading aloud involves a similar transfer of impressions from the visual area to the motor speech area. The word impression is received in the region bordering the calcarine fissure. Nerve currents spread from there to the associat-

ing regions near the border between the occipital and parietal lobes on the lateral surface of the cerebrum. This corresponds to the process of understanding the word. From there impulses spread forward to the motor speech area, from which the separate centers for the muscles involved in speech are aroused to action. In all speech disturbances there is a tendency to recovery after the first injury. This is in part due to the recovery from the physical injury, but it must be ascribed in larger measure (to the development of new paths to take the place of the old) to the transfer of the functions to portions of the cortex not previously used.

Variations in Localization. — This leads to a much larger problem. Lashley, and in less degree Head, (have argued that the functions in the brain are not so definitely localized as we have pictured them, that there is always a considerable variation from individual to individual in the part of the brain which is used in a given function.) Lashley goes so far, on the basis of experiments with rats in learning mazes, as to assert that all parts of the brain have approximately the same functions and that what counts in determining the degree of injury is the amount of tissue that is destroyed and not the part of the cortex that is injured. He would explain aphasia in the same way. Many aphasic cases retain some of the speech functions. Very familiar expressions are retained when the less familiar have been lost. Some old aphasics can swear volubly although they can say very little in the ordinary conversational forms. (Lashley says that, if only slight injury has been done to any part of the cortex, speech will be mildly disturbed and the degree of disturbance will increase with the amount of tissue destroyed. The alternative interpretation is to assume

that there is originally a fairly definite localization, but that when one part is destroyed another will take its place. It cannot be said that there is agreement between the two. For a century, opinion has been shifting between these extremes. The question is still open.

Right-Handedness and Left-Brainedness. — The fact that the speech functions are associated with the left cortex is but one indication of the fact that the left brain in right-handed individuals dominates the activity of the right in almost everything. The more delicate actions are executed with the right hand because the left brain is more certain in its responses. Apparently the right brain is controlled in its more accurate responses from the left. If the individual is left-handed, the right brain controls, and in that case the speech centers are in the right hemisphere.

Sensory Recall in the Cortex. — The cortex not only has the function of arousing movement when sense impressions affect it, but we have every reason to believe that one sensory area may occasion activity in another sensory area. Thus when, in the dark, a dog places his muzzle against the hand, the visual image of the dog will be evoked by the tactual impression either as one moves or before one moves, according as the stimulus is expected or unexpected. We may assume that the tactual neurones in the parietal region arouse the visual neurones in the occipital area. Much of perception consists in interpretations that are due to associative transfers of this kind. Very often the stimulus and the associations it arouses leads to action of some sort, but, so far as important action is concerned, that may be delayed for minutes or days.

Closely related is the question of the memory processes. A memory is a rearoused process similar to the picture of

the dog. (We have every reason to believe that the memory image is connected with the same cortical region, probably with the same cortical neurones as the original sensation.) The region of the cortex that was in action during the original stimulus is rearoused through a connection with another sensory stimulus at the time of the recall. There is some slight evidence that memories can be rearoused by direct stimulation of the cortex. Monkeys whose brains have been exposed will, when the occipital region is stimulated, make movements as if they were seeing bits of food before them. After operations for a tumor in the occipital region patients have reported that visual memories long lost will be again recovered on occasion of suitable suggestions.

Note

Nerve Elements Do Not Act in Isolation. —(Before we leave the topic we should insist that the single parts of the nervous system probably do not act alone. When we speak of the action of a single group of cells, it is probable that the group is merely the center of excitation in a very wide region. The excitation that arouses that group spreads to very remote parts of the brain) Action is always of large masses of nerve-cells, but of the mass certain parts are emphasized, the others respond in very much slighter degree. There is a complicated interplay of part and part throughout a very large portion of the mass of neurones, although only relatively few are in great activity. The interactions which themselves do not directly affect action serve to guide the course of the other responses. Each contributes its share to the total action, although one alone stands out prominently.

N.B.

The action of the nervous system, then, is always dependent upon a transfer of some sort of energy from neurone to

neurone. The original excitation is received from the external world and has its final outcome in some sort of movement. At least two sets of neurones are involved in every action. As the act becomes more complicated, a larger and larger number of neurones intervene, and a larger and larger number of stimuli contribute to the excitation and control of the movement. At the lowest level the stimulus is ordinarily single or at least of one sort, and the paths of motor discharge are relatively few. At the second level the neurones involved are still relatively few, but the stimuli are numerous and varied and the paths of discharge are more numerous. On the highest level in the cortex very many of the sensory and motor paths are concerned, and in addition the effects of the stimuli that were earlier received and are stored in the nervous system contribute their share to the control of action.

Interaction between Cord and Cortex. — The different levels ordinarily interact in any response. Thus, when the hand is burned or pricked, it will usually be drawn back reflexly. This means that the sensory impulse is transmitted to a spinal ganglion and thence to the anterior gray cells of the cord, and so down to the muscle. But suppose that the man is working in a bit of machinery with a knife back of the hand, and the finger is burned. The reflex, if it is not too strong or if the stimulus is not unexpected, will be checked by the knowledge of the danger from the knife. This means that the visual impression of the knife has been carried to the visual area in the cortex by way of the eye and mid-brain centers. The effect of the arousal of the visual area is transferred to the motor region, and inhibits the activity of the motor cells in the cord that would otherwise start the reflex. It may even contract the muscles

that oppose the reflex. In this way the impressions from the eye, or the memories of sensations earlier derived from the eye, oppose and may overcome the effects of the excitations from the skin. The movement is controlled, not by the tactual sensations alone, but by tactual sensations together with any visual sensations and memories that bear upon the situation. At each level in the nervous system as we go upward from the cord, there are more neurones involved. The action is dominated by a constantly increasing number of sensory nerve currents, and many more forms of response are possible. But the difference is one of complexity alone. The impulse is propagated in the same way and the laws that determine the selection of the path are the same. Our first picture of the nature of the simple reflex explains the fundamentals of the most complicated voluntary act. It is only necessary to add new stimuli and new possibilities of response, — to recognize that many new units of nervous activity are adding their quota to the whole that results in action.

QUESTIONS

1. What are the elements of the nervous system? What animals are they most like? neurilemma

2. What is the sheath of the axone? How can we distinguish between neurilemma and medullary sheath?

3. Describe the function of the nervous system in the simplest and most general terms.

4. What is the starting point of all action? To what does all stimulation of the senses lead?

5. What passes along the nerve as an impulse is transmitted?

6. How are the acts of cord, cerebellum, and cerebrum alike? In what do they differ?

7. What parts of the nervous system are involved in the following acts?

Drawing up the foot when the sole is tickled. Top
Sneezing when smoke is breathed.
Winking as the eye is threatened. back
Turning a corner as you think of something else.
Reading a sign aloud. left side

8. What difference is there between the action of the projection and association areas in the cortex of the cerebrum?

9. Why does injury to the right side of the brain paralyze the left side of the body?

10. Why is the right side of the body frequently paralyzed in cases of aphasia?

EXERCISES

1. Draw neurones of three different types. Designate axones, dendrites, and end-brush of each.

2. Draw a diagram to illustrate the path followed by the nerve current when you burn your finger and draw back your hand.

3. Draw a cross section of the cord. Show the path followed by a simple reflex.

4. Draw the cerebrum in lateral and mesial view. Indicate the sensory, motor, and association areas.

5. Trace on the diagram the parts of the brain that are active as you copy a sentence from a book.

6. If possible examine a section of the cord under a microscope. Draw the 'T-shaped' neurones, anterior ganglion cells, and their connections.

7. If you can, dissect the brain of a cat, sheep, or other animal. Compare the structures with the diagrams.

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CHAPTER III

SENSATION

In discussing the behaviour of man, we have the choice between beginning with the acts or with the stimulations that evoke them. Two considerations have led us to discuss first the sensory elements. First, all action is directly the result of the excitation of some sense-organ and so the receiving organ must be known if we are to understand an act. In the second place, all consciousness is composed of sensory elements and all treatment of knowledge must depend upon a preliminary analysis of the qualities that compose it. We shall have to consider the sense-organs that constitute the initial link in the chain of neurones that makes possible all acts, and the way that they may be excited. From this we may make an enumeration of the sensory qualities that enter into our knowledge.

The Components of Consciousness. — At this moment the consciousness of the reader is a very complex affair. Stimulations are falling upon the retina that arouse immediate sensations and by suggestion and association old memories that together constitute what you call the perception of the book. You are vaguely aware of the noise of the traffic in the street, which you exclude so far as possible that it may not interfere with your task. As your eye wanders over the page you not merely receive the black of the letters against the white of the page, but they suggest certain words and these in turn elements of knowl-

edge. Your mind wanders now and again to the thought of the game you would like to be having or of the recitation you would like to make on the morrow, or to the entertainment of the evening, or to some other topic. Accompanying each of these processes are feelings of pleasure or displeasure, and in many cases emotions of greater or less intensity. Obviously even the simplest consciousness is a very complex affair. To describe or classify the elements of consciousness by simple observation would be an endless task. Fortunately several general principles have been established which greatly simplify it.

The Qualities of Memory Are the Qualities of Sensation. — The first of these principles is that the processes of memory and imagination have approximately the same qualities as the sensations. A remembered or imagined red is of the same quality, approximately, as the red that is seen directly. Leaving aside the feeling processes for the moment, we may say that the qualities of consciousness are the qualities of sense. Since Locke it has been an axiom of psychology that there is nothing in mind that was not previously in sense. It is true undoubtedly that one cannot think of a colour that has never been seen. Try to picture to yourself what the ultra-violet waves would be like to an eye that had developed a capacity to see them, and you will find that each colour you call up is compounded out of those already familiar. All attempts to produce an imaginary quality that has not been received through some sense-organ are fruitless. Every quality of memory and imagination is received through the senses. New things may be compounded out of these qualities, but the number of qualities is fixed by these elementary sensations. Evidently, then, our first problem in the analysis of conscious-

Aquinas

Note

ness is to determine the number of sensory qualities. The accomplishment of this task will also give us the extreme limit of the number of qualities that may be remembered and imagined as well.

The Doctrine of Specific Energies of Sense-Organs. — The second general principle that will guide us in determining the different sensory qualities is the doctrine of specific energies. This began as a theory suggested by Johannes Müller, the father of modern physiology, and has been developed into a doctrine that covers all sensory processes. Briefly, this law asserts that any sense-organ must always give its own quality of sensation, no matter how it may be excited. Note Simplest evidence of this may be offered by pressing the eyeball with the finger. You will notice about the circle of pressure a ring of light of a quality that might have been induced by a ray of light. An electric current passed through the eye will also produce a visual sensation, as will jarring the optical apparatus by falling (' seeing stars '). Conversely, it may be said that there can be no more qualities of sensation than there are different kinds of sensory end-organs. If the quality of the sensation depends upon the character of the sense-organ that receives it, and not upon the nature of the stimulus, the number of sense qualities must be as great as, and no greater than, the number of sensory ends. Note Since the same form of physical energy will in many cases excite several different sense-organs and evoke a different sensation from each, the difference must be due to the organ, not to the stimulus. Many instances may be cited. A long light-wave excites the sensation red upon the retina of the eye, a sensation of warmth upon the skin. The electric current gives a different sense quality for each sense-organ, — pain on the skin, sweet on

the tongue, and so on. If we accept this law, it follows that we can determine the number of different kinds of sensation if we can discover the number of kinds of distinct sensory end-organs. Note

The Development of Sensations. — The development of the sense qualities depends upon and goes hand in hand with the development of the sensory endings. In the simplest organisms there is no differentiation of sensory tissue, and consciousness probably shows no differences whatever. All stimuli give rise to exactly the same effect. Taste is not different from touch, sight from hearing, — if hearing be present at all. All forms of stimuli excite the same organ and in consequence must give the same effect. As differentiation takes place in the animal series, new organs are developed and new sense qualities make their appearance. At the level of insects most of the senses found in man are pretty well differentiated. Even in man, however, not all of the physical stimuli have corresponding sensations. The electric and magnetic forces have no sense-organs and are not recognized as separate qualities. For that reason, possibly, knowledge of electrical and magnetic phenomena developed relatively late. Indirect evidence, obtained through the other senses, alone gives knowledge of their existence. Our problem in this chapter is to determine the number of different kinds of sensory ends that the human organism presents to the external world, confident that this will also give the number of distinct conscious qualities.

Sensations of Temperature. — We may begin with the sensations derived from the skin, since the skin is probably the simplest of the sense-organs, although far more complex than one is inclined to believe. The ordinary assumption

1. consisting of parts all of the same kind.

seems to be that the skin is a comparatively homogeneous surface with but one sense quality. Recent investigation, beginning in the early eighties of the last century, has shown that the skin has four senses and that each is distinct in quality and in sensory ending. Two of these respond primarily to mechanical stimulation, two to temperature. The mechanical senses are pressure and pain, the temperature senses are warmth and cold. Evidence for the two temperature senses is most readily obtained by the beginner. If one will pass the point of a rod heated above the body temperature slowly over the skin, one will notice that the rod feels warm only here and there at points well separated. These spots were found by von Frey to average about one and one-half to the square centimeter. If the rod be cooled below the temperature of the skin, cold is noticed at many more spots, about thirteen to the square centimeter, but still wide areas without temperature sensations intervene. While, then, the physicist assures us that cold is nothing but the absence of heat so far as energy is concerned, it is not to be doubted that, physiologically and psychologically, cold is just as truly a distinct sensation as warmth. Not only is it proved by mapping the spots that the temperature senses are distinct, but the result is confirmed by a number of related facts. (1) Stimulation of a well-marked cold spot always gives cold only, no matter what the source. Pressure, the electric current, even the warmth obtained by concentrating the sun's rays upon the spot by a small lens, all give the same sensation of cold. Warm spots may also be aroused by inadequate stimuli but they require greater intensity than the cold spots. (2) Certain parts of the body, the cornea of the eye, *e.g.* lack warm spots altogether, and there are relatively large areas where cold spots are

lacking. (3) Certain chemicals, *e.g.* menthol for cold, carbon dioxide for warm, will excite one sort of spot, but not the other. All these facts go to show that cold and warmth are independent senses with independent nerve ends in the skin.

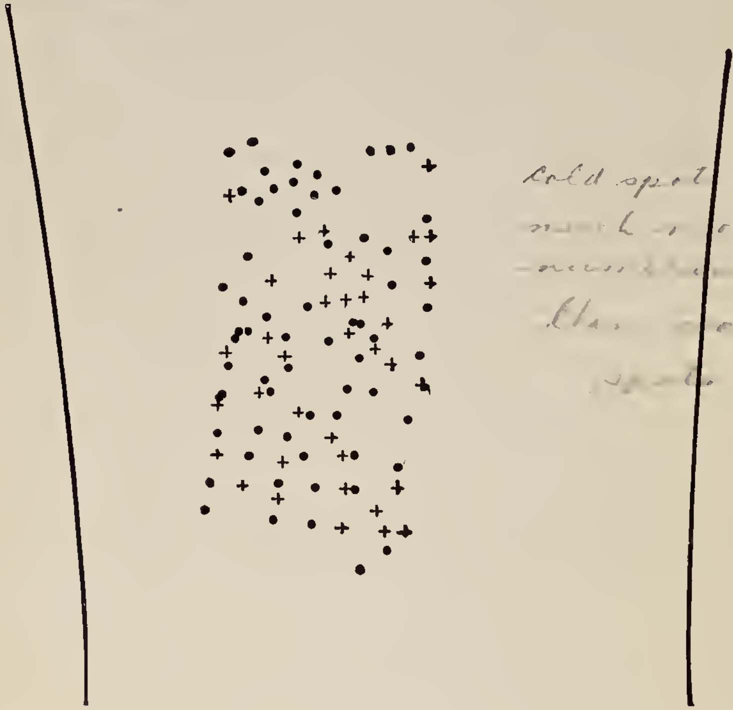

FIG. 12. — Map of warm and cold spots on volar surface of forearm. The dots represent warm spots as tested at a temperature of 41°–48° C.; the crosses, cold spots as tested at 10°. (From Howell, after von Frey.)

Physiological Temperature Scale. — The response of the nerve ends to the different changes in temperature is indicated in the accompanying diagram. The physiological zero point lies somewhere in the neighbourhood of 30° C. The variation is from 28° or below to 34° or above, according

to the temperature to which the body has been adjusted. At any one time the limit will be only a fraction of a degree. Below this point all temperatures excite the cold organ; above, all excite the organ of warmth. Very low temperatures, from 12° downward, also excite the nerves of pain

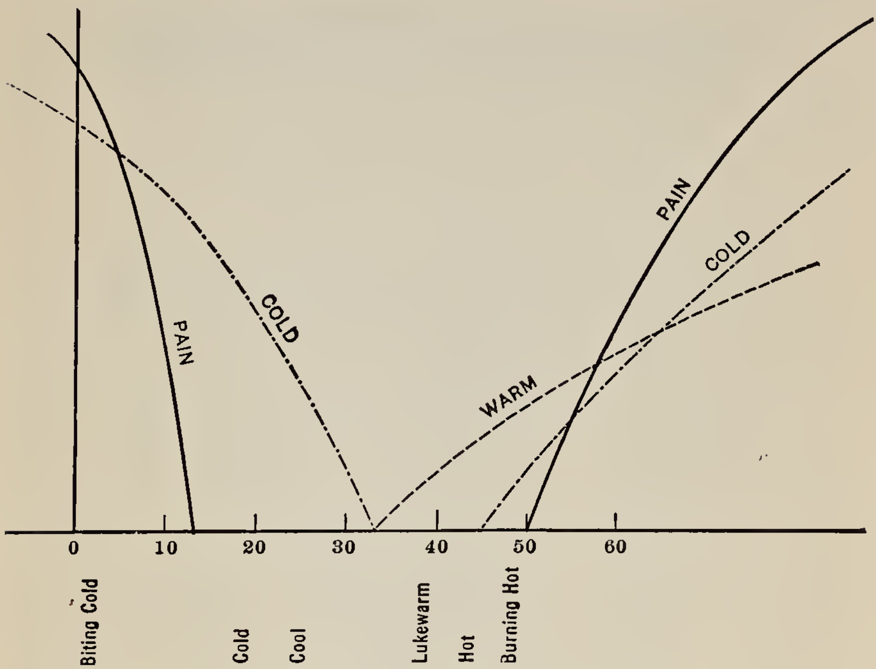

FIG. 13. — Shows the sense-organs stimulated, and approximate degree of stimulation at the different temperatures. The figures on the base line indicate the temperature in centigrade, the height of the line the amount of stimulation. (After von Frey, *Vorlesungen über Physiologie.*)

which give the sensation of burning or biting cold. Above the neutral point, at about 45° C., warm becomes hot. In consciousness it is marked off from warm by a very sharp line. Physiologically, the difference is due to the presence of the sensation of cold. Hot is a compound of warm and cold. This excitation of cold spots by heat has been called

the paradoxical cold sensation. Beyond this, at some 50° C., pain is also aroused and gives burning heat. All the temperature effects are produced by combinations of the excitations of the three sense endings of cold, warmth, and pain.

Cutaneous Sensations from Mechanical Stimuli. — Two sense qualities may be excited mechanically, pressure and pain. Somewhat the same differentiation must be made between them as between the temperature senses. Gentle pressure upon the skin with a sharply pointed wooden rod or a short hair is felt only here and there. These points are known as the pressure spots. They are found closer together on the average than warm or cold spots. They vary from about nine to some three hundred to the centimeter. These pressure spots are relatively easy to excite, — they are affected by hairs that exert a pressure of little more than a milligram. The pain spots are much closer together and require greater pressure for their stimulation. They are most easily found by pressing upon the different points on the skin with a well-sharpened horsehair. It has been shown that 200 or more points to the centimeter give rise to the pain sensations. That pain is not merely a more intense pressure, as was thought for a long time, is proved (1) by the fact that a pressure spot always responds more quickly than a pain spot, and (2) that certain parts of the body are sensitive to pressure but not to pain, *e.g.* the inner membrane of the cheek, while the cornea of the eye always responds with pain, never with pressure, no matter how slight the excitation. Again, (3) certain drugs destroy one sense quality and leave the other unaffected, *e.g.* cocaine when first applied destroys the sensitiveness to pain but not to pressure; a rare drug, saponin, destroys sensitiveness

to pressure but not to pain. It is now generally held that pain and pressure are distinct senses with distinct kinds of sensory endings in the skin.

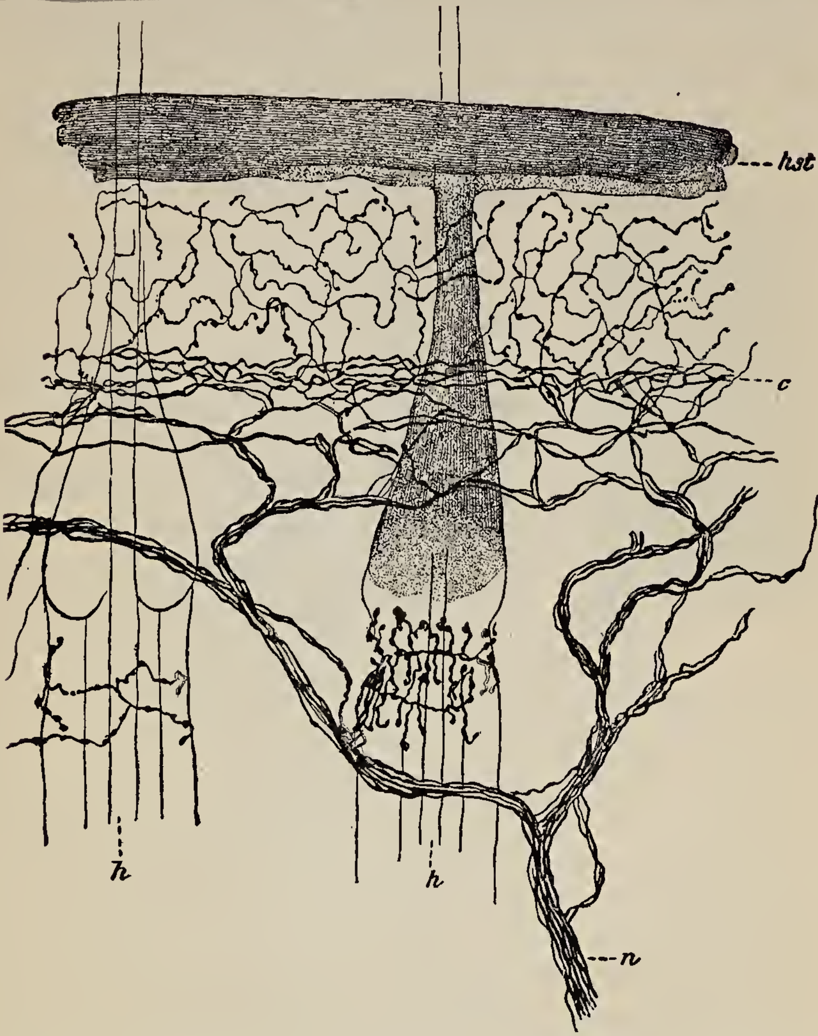

FIG. 14. — Nerve endings in skin and about hair follicles. (*hst*) superficial layer of epidermis. (*c*) the most superficial plexus of nerve fibers in the true skin, free nerve endings still nearer the surface; (*h*) the hair with nerves about the root; (*n*) cutaneous nerve. (From Barker, after Retzius.)

The Organs of Cutaneous Sensation. — Pressure and pain may with some certainty be referred to particular sense-organs. The nerves of pressure for the greater part of the body are the nerves at the roots of the hairs, as illustrated in the accompanying diagram. On the palms of the hands and the soles of the feet where hairs are lacking, the organ of pressure is the touch corpuscle of Meissner found in the papillæ of the skin. (Figure 15.) The nerves of pain are the free nerve ends that extend into the outer skin. They too may be seen in Figure 14. That pain has a very superficial organ is evident from the fact that an acid will give rise to pain before it affects any other of the sense ends. It needs only to eat into the most superficial layer of the skin, and the sensation of pain is aroused. The organs of warmth and cold have not been made out with so much certainty. The skin, then, is not a single sense-organ, but a mosaic in which four separate senses may be distinguished, each with a special end-organ. These are pressure, pain, warmth, and cold. With their combinations they give rise to all knowledge of the outer world obtained through the skin.

FIG. 15. — Tactile corpuscle of Meissner from the skin of toe. (*N*) nerve fiber. (From Barker, after Schiefferdecker.)

The Gustatory Sensations. — The principles established for touch can be readily transferred to taste. As every one knows, the chief organ of taste is the tongue. More particularly the sense endings of taste are to be found on the sides of the foliate, the fungiform, and the circumvallate

papillæ on the tongue. Essentially the papillæ are folds or little pits on the surface of the tongue. The sense endings proper are the taste beakers which are arranged along the sides of the depressions formed by the papillæ. The beaker itself, as may be seen from the diagram, is a group of nerve

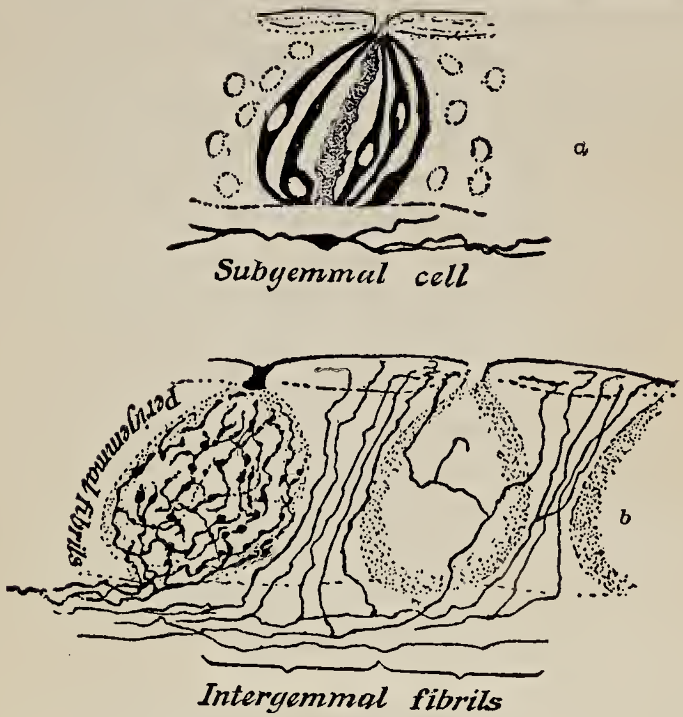

Fig. 16. — Taste-buds and endings of gustatory nerves. (*a*) shows taste cells about a central supporting cell; (*b*) fibrils around and between the taste-buds. (From Barker.)

ends interspersed with supporting cells. The whole looks not unlike a flower bud. The papillæ are scattered fairly thickly over the tip, sides, and back of the tongue. The fungiform can be seen on the tip of the tongue as little bright red depressions. Four separate taste qualities are distinguished, — sweet, salt, sour, and bitter. The different

qualities cannot be so easily connected with different spots on the tongue as can the touch qualities with spots on the skin. The taste-buds are well concealed in the papillæ and a single papilla often possesses more than one quality. It is assumed, however, that each taste beaker responds to but one quality, although several beakers of different kinds may be present in the same papilla. In general, sweet is perceived on the tip, sour on the sides of the tongue, bitter on the back, while salt is pretty evenly distributed. At the most this arrangement is only partly carried out, and there are many exceptions. The best evidence for the doctrine of specific energies is the fact that different drugs dull or destroy the capacity to discriminate different tastes in different degrees. Cocaine, for example, first destroys the sensitiveness to bitter and affects the other tastes more slowly. Gymnemic acid first destroys the sensitiveness to sweet. The time required for the nerves to respond is also different for each taste. These facts together seem sufficient to justify the statement that the four taste qualities have each a special sort of taste beaker, although several different sorts of beakers are usually found in a single papilla.

Combination of Taste with Other Sensations. — One may be inclined to question the statement that only four taste qualities can be distinguished, for certainly ordinary experience seems to show a large number. This objection must be admitted. The other qualities are, however, not tastes but additions from other senses. The most evident are the ordinary cutaneous sensations. Temperature seems to modify taste, as is seen in the peculiar effect of the cold of ice cream or the heat of coffee. Melted cream seems to have a different taste from the frozen; cold or lukewarm

coffee, from hot. Roughness or smoothness adds a quality not easily distinguished from taste. Witness the difference between granulated and pulverized sugar. Other instances will be recalled by the practical housewife. (By far the most important additions are those that are made by smell.) Note Most of what we seem to taste we really smell. All of the delicate tastes, so called, are largely odours that reach the sensory region in the nose by way of the inner air passages. Note (That much of the taste of food is really received through the nose is evident from the fact that a cold destroys nearly all taste.) Moreover, if the nostrils be closed, substances will be confused that ordinarily are easily distinguished. Cinnamon is said not to be distinguishable from flour under these circumstances. In short, in what is ordinarily called taste we have a mixture of the four simple tastes with the qualities of cutaneous sensation and with odour. N.b. (The stimulus for taste is some chemical dissolved in a liquid and brought into contact with the taste-buds by being caught in the papillæ. A substance to be tasted must be dissolved either before it is taken into the mouth or by the saliva.

Sensations of Smell. — Of the sense of smell we know practically nothing. All that can be determined is that the organ of smell is the olfactory membrane in the upper nasal cavity. The sense nerves are simple cells with hairlike projections that come to the surface of the membrane between supporting cells. In their structure they are the simplest of the sense-organs. The stimulus for odours is some chemical substance carried to the olfactory membrane in particles. It produces some chemical change in the sense ending and this starts the nervous impulse toward the brain.

No definite answer can be given to the question of the number of different organs and the number of different

olfactory qualities. Two men have devoted much time to analysis and experimentation on smell. Zwaardemaaker, a Dutch physiologist, came to the conclusion that there were nine specific qualities. Henning more recently published a book in which he gave his evidence that there were six:

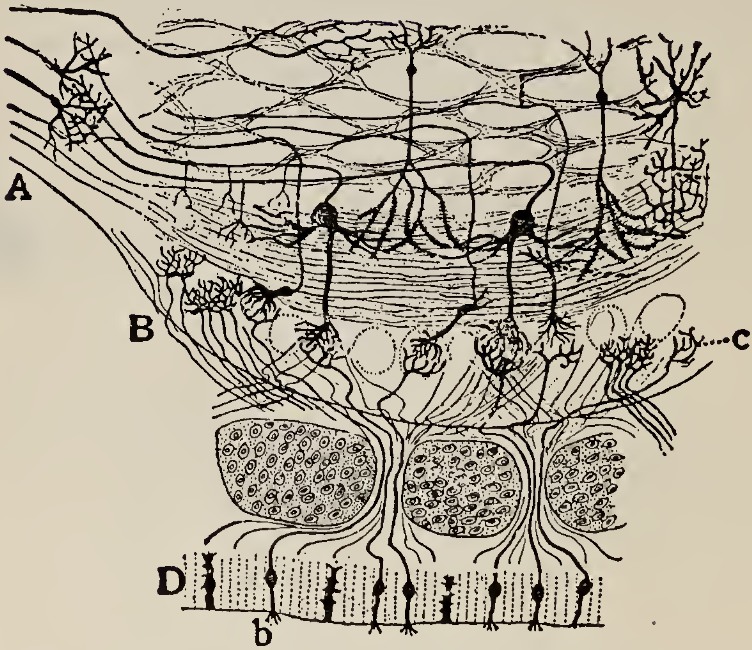

FIG. 17. — (A) the olfactory lobe; (B) olfactory bulb; (D) nasal mucous membrane; (b) peripheral olfactory neurone; (c) synapse of neurone in the glomerulus of the olfactory bulb.

(1) spicy; (2) flowery; (3) fruity; (4) resinous, illustrated by turpentine, varnish, etc.; (5) foul, the odour of hydrogen sulphide and decaying animal matter; and (6) scorched, as represented by burning substances or hot tar. These simple qualities combine to produce the other familiar odours. Thus coffee as you drink it would be a combination

of the tastes of sweet and possibly bitter with the odours of scorched and resinous. Still later workers obtained results that throw some doubt upon the finality of Henning's conclusions. Still his results and certain facts connected with pathology and with fatigue indicate that there are different organs for the different odours. In diseased conditions a patient may lack one class of odours alone. Also the nose may be fatigued for one odour and remain sensitive to others. After one has smelled camphor for some time, alcohol will not be noticed, but iodine will still have its usual effect. While these experiments are suggestive of the presence of distinct sense-organs for different odours, they have not been carried far enough to determine the number of qualities. The uncertainties of science are reflected in the popular speech. There are no names for odours other than those of the objects that give rise to them. The difficulty is increased by the fact that tactual and taste qualities mix with the olfactory. The sweet odour of chloroform is really a taste. The odour of ammonia is largely pain, and the resulting holding of the breath adds a feeling of suffocation. Zwaardemaaker classes as nauseating certain odours that receive their peculiar quality from the incipient retching reflexes excited in the throat. Of smell we know only that the organ is simple and has its seat in the upper nasal passages, that there are distinguishable qualities, but that their number is uncertain, and that smell combines with taste and tactual impressions to produce very complex fusions. Here Note

Hearing. — The first of the so-called higher senses is hearing. It is higher in its importance for the mental life, in the degree of complexity of the organ, and in the richness of its qualities. In each of the higher senses we must con-

amplitude – breadth, abundance;

sider the sense excitation at three different stages: (*a*) the physical stimulus, (*b*) the change excited in the sense-organ, and (*c*) the resulting conscious qualities. The stimulus for hearing, physics teaches, is vibration in the air. The wave-lengths vary in three ways: in the rate of their vibration, in the distance through which the particles vibrate or the amplitude of vibration, and in the form or complexity of the wave. The rate of vibration corresponds to the pitch of the tone, the amplitude corresponds to the intensity of the tone, and the form to the timbre or tone colour. The form of the wave gives the tone of each instrument its character, *e.g.* the C of the violin differs from the C of the piano only in its wave form.

Structure of the Ear. — The organ of hearing is the ear. The ear is for convenience of description divided into three parts, — the external ear, the middle ear or drum, and the inner ear or labyrinth. The outer ear is the trumpet of cartilage, popularly called the ear, together with the tube that extends into the skull. Its only function is to gather the sound-waves and bring them to the drum. The middle ear extends from the membrane of the drum backward to the bony inner ear. In essentials the middle ear is an irregularly shaped hollow in the skull separated from the outer world by the drum membrane, and connected with the throat by the Eustachian tube. So far as it concerns us, it is a cavity across which extends a chain of three bones, the hammer, anvil, and stirrup, from the membrane of the drum to the oval window of the labyrinth. The drum head is a membrane stretched obliquely across the opening of the ear. On its inner surface is the handle of the hammer. The head of the hammer fits into the anvil, and this is attached to the head of the stirrup. Each bone receives its

name from its shape. When a sound-wave strikes against the membrane of the drum, the membrane is forced inward slightly, and this inward motion carries the handle of the hammer with it. The hammer and the other bones revolve about a ligament attached to the top of the middle ear.

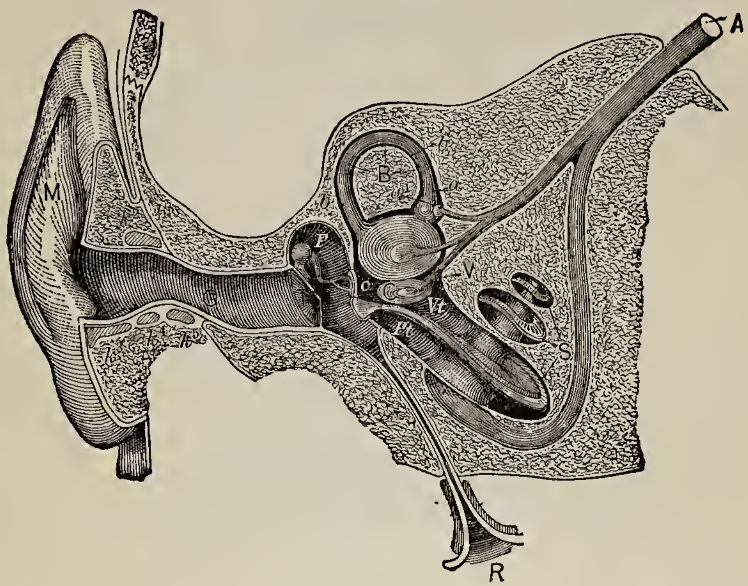

FIG. 18. — Diagram of ear showing general relations of parts (schematic) (*M*) and (*G*) external ear; (*P*) middle ear with small bones; (*o*) oval window; (*Vt*) scala vestibuli; (*Pt*) scala tympani; (*S*) cochlea; (*C*) sacculus; (*V*) vestibular nerve; (*B*) a semicircular canal; (*A*) auditory nerve; (*R*) Eustachian tube. (From Calkins' *Psychology* after Czermak.) In this cut the cochlea is turned 90° from its true position. The top of the cochlea is really turned toward the observer.

The pressure of the air wave upon the drum membrane turns the bones about this as a pivot, and the stirrup communicates the motion to the liquid of the inner ear. When the pressure of the air is relaxed, the membrane of the drum returns to its original position or a little beyond and carries

with it the chain of bones and the foot of the stirrup. The foot of the stirrup fits closely into the oval window of the inner ear, and the joint is closed by a delicate membrane that makes the whole water-tight. While this is the ordi-

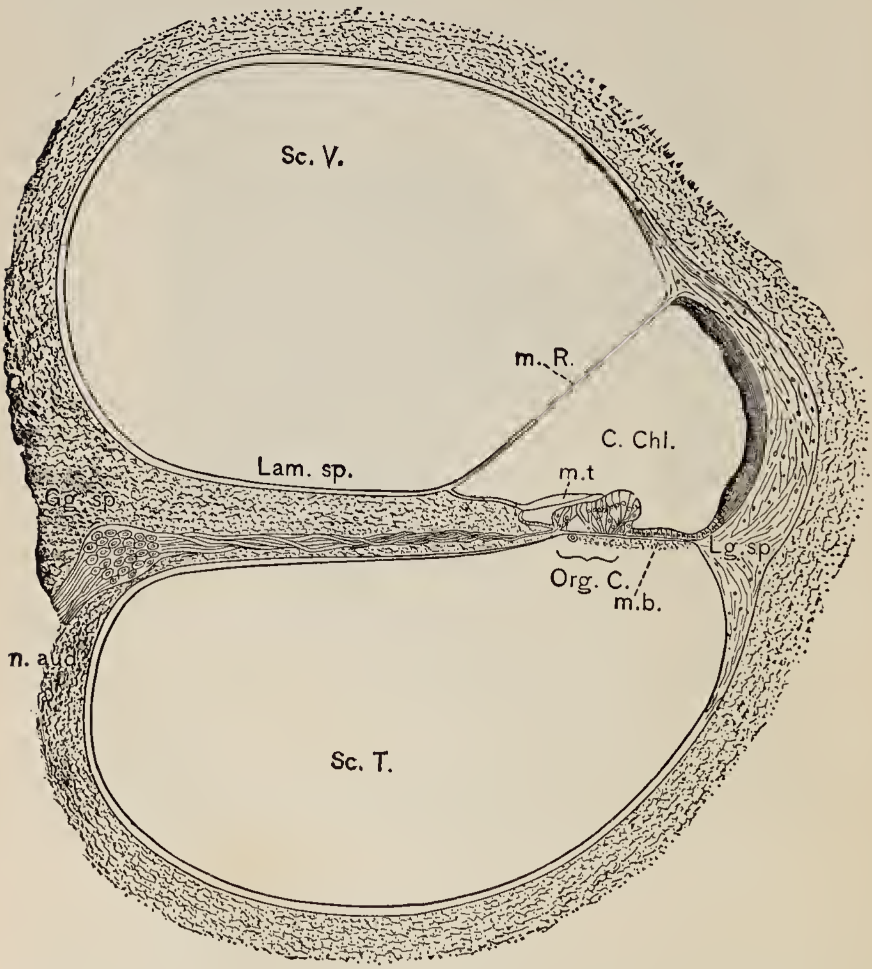

FIG. 19.—Section of the tube of the cochlea. (Lam. sp.) lamina spiralis through which the nerve passes; (n. aud.) auditory nerve; (Org. C.) organ of Corti; (m. b.) basilar membrane; (m. t.) tectorial membrane; (C. Chl.) cochlear canal; (Sc. V.) scala vestibuli; (m. R.) Reissner's membrane; (Sc. T.) scale tympani.

nary course of stimulation, high tones apparently pass through the bones of the head. In some cases, too, hearing is normal when the bones have been destroyed by disease.

The Mechanics of the Cochlear Vibration. — The movement of the stirrup transmits the excitation to the inner ear, the point where hearing as a nervous process begins. The auditory portion of the ear is the cochlea. The cochlea, as its name implies, is a tube coiled up like a snail shell for two and a half turns. It is divided down the middle by a ridge of bone and a thin membrane known as the basilar membrane. Figure 19 shows a cross section of the tube of the cochlea. The vibration of the liquid is rendered possible by the round window, an opening in the bony wall, closed by a delicate membrane. It is below the oval window, at the point marked *Pt* in Figure 18. Pressure upon the stirrup at the oval window is transmitted through the entire length of the cochlear fluid to the round window. The membrane gives and moves the fluid. The vibrations of the outer air push the membrane of the drum in and out. The drum head starts an oscillation of the chain of bones, the stirrup presses against the liquid of the inner ear, and this is permitted to vibrate by the delicate membrane of the round window.

The Helmholtz Theory of Hearing. — All of this is only preparation for the excitation of the nerve of hearing. The nerve of hearing ends in connection with the fibers of the basilar membrane. The exact connection between the nerve fibers and the fibers of the basilar membrane has not been altogether made out, (but nerve fibers come through the spiral of bone and end in connection with hairs upon the basilar membrane.) These hairs are excited in some way by the vibrations of the basilar membrane and they, Note

in turn, excite the auditory nerve. The most generally accepted theory of hearing was suggested by Helmholtz, who regarded the basilar membrane as a series of strings like the strings of a piano. Each string is tuned to some one of the audible tones. Whenever the tone to which a string is tuned is represented in the vibrations of the liquid of the inner ear, that string is thrown into sympathetic vibration. The vibration of the fiber starts a nervous impulse in the nerve connected with it, and this impulse is transmitted to the brain through a series of neurones. The sensation of sound makes its appearance upon the excitation of cells in the temporal lobes of the cortex. The process of exciting a vibration in the fiber is very similar to that which accompanies speaking into a piano when the keys are held down. When you speak, the strings tuned to your voice are excited sympathetically and can be heard after you finish speaking.

Evidence for and against the Helmholtz Theory. — In the basilar membrane the fibers are said to number between eighteen and twenty thousand, while the tones that can be distinguished by the ordinary ear have been computed at approximately eleven thousand. The number of strings is then sufficient for the tones that may be heard. The case for the Helmholtz theory is strengthened by the limited number of tones that may be appreciated. The upper and lower limit of hearing may be explained by the limited number of fibers. The lowest tone that may be heard has approximately sixteen vibrations per second; the highest varies from about thirty thousand to forty-five thousand per second. Another strong bit of evidence for the theory is that after death there have been found in individuals who were deaf to certain notes of the scale only, regions of

the basilar membrane in which disease had destroyed the fibers.

Three objections to the Helmholtz theory are most important. First is the slight probability that fibers as short as those of the basilar membrane, only from 0.04 to 0.48 mm., can vibrate to waves as long as those that we hear. Second, the fibers of the basilar membrane are interlaced and covered on both sides by tissues so that it is not possible that they should vibrate independently. Thirdly, the details of the mechanism by which the vibration should stimulate the nerve of hearing that ends in hair cells some distance above the fibers cannot be made out. The alternative theories suggest that the hair cells are stimulated directly by the oscillations in the liquid, would make each nerve respond to all vibrations, and assign the analysis to the brain rather than to the ear. On the whole the Helmholtz theory has the advantage in the argument.

Complex Tones and Noises. — Very important is the explanation of the complex tones, for most tones are complex. We may assume the Helmholtz theory tentatively and refer the facts of complex tones to it. A complex tone like a note of the piano would be made up of one tone, the fundamental, and of others of a rate two, three, four, and other even multiples of that rate. The timbre of the tone varies with the number and character of the overtones. In the violin tone the high overtones predominate; in the piano tone the overtones decrease in strength as they increase in pitch. In the ear each of these overtones is taken up by a different fiber and is carried to the cortex separately. In consciousness they ordinarily fuse to form a single quality, although by close attention the elements may be distinguished. What then in the air is fused into a single

fundamental - primary
in music - lowest note of chord.

wave of characteristic form is analyzed by the basilar membrane into its separate elements and reunited in consciousness to form a complex tone. Noises of the continuous kind may be regarded as very complex tones made up of many vibration rates that have no simple arithmetical relation to each other. Each is received by a separate fiber and transmitted to the cortex, where the result is a jumble of sensations. The single crash or crack, the second form of noise, arises from a twitch of the fiber of the membrane that does not persist long enough to give a full tone. Any tone will give a single puff of noise if it is permitted to affect the ear during but two full vibrations. In either case the noise is heard by the same part of the ear that perceives the tone, the fibers of the basilar membrane in the cochlea.

The Qualities of Spoken Sounds. — An important instance of compound auditory qualities is furnished by the sounds of letters. The fundamental pitch of each vowel sound and probably of many consonant sounds is determined by the vibrations of the vocal cords. The specific differences between the vowels is produced by added component tones that depend upon the vibration of the air in the mouth cavity. The cavity is large as you speak *oo*, smaller for *o*, and very small for *ē*. The consonant sounds would be more complicated with large components of noise for most. The fundamental may change as in singing while the overtone remains the same, and so the vowels and consonants may still be recognized. A vowel quality depends upon the presence of one or more characteristic tones in addition to the fundamental. The long *ee* in ‘meet’ depends for its quality upon a principal tone at 300 vibrations and less intense one at about 2300. The long *a* of ‘ate’ has a principal component at 500 vibrations

and a slighter one near 1900. These components cover a fairly wide range and the value given is for the note of greatest intensity.

Summary. — In short, vibration in the air is received by the membrane of the drum and is transmitted to the oval

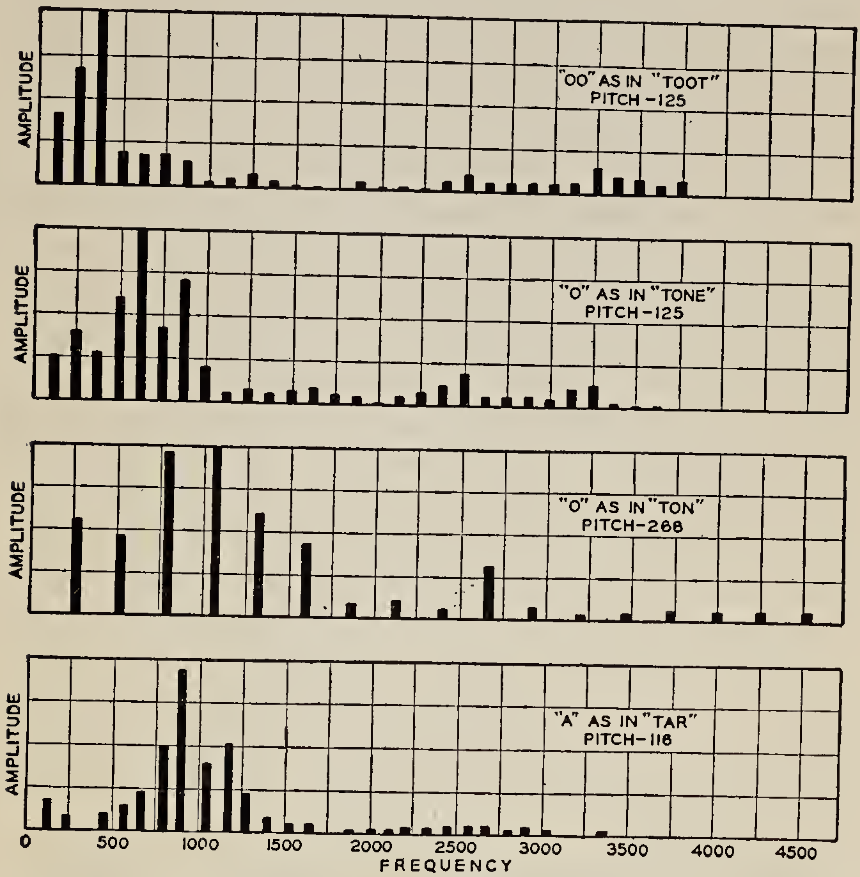

FIG. 20. — Shows the varying components of different vowels. The pitch of the fundamental is given under the sound in the upper right portion of each graph. The black bars indicate the pitch of the different components by their position on the scale. The numbers at the bottom give the vibrations per second of each. The height of the bar shows the relative strength of each component. (From Fletcher, *Speech and Hearing*, by permission of D. Van Nostrand Company, publisher.)

window through the chain of small bones. At the oval window the oscillations of the bones produce vibrations in the liquid of the inner ear. The several tones are received by the different fibers of the basilar membrane attuned to them. The vibration of the fibers excites a change in the auditory nerve, and the nervous impulse is carried to the cortex, where sensation arises. It is still a question whether we are to assume that each fiber has its own quality of sensation and that there are therefore eleven thousand distinct sensations and eleven thousand distinct sorts of nerve fiber, (Note) or whether the different fibers are grouped in some way in larger classes. The objection to the assumption of so many distinct nerve processes and sensations is that it gives hearing a disproportionate number of qualities when compared with the other senses. More cogent is the argument that notes an octave apart seem more alike than notes within the octave. Two C's are more likely to be confused than C and G, or C and B. But if we assume that there are fewer simple primary qualities than there are distinguishable tones, there is as yet no agreement as to what these primary qualities are, or how many there are of them.

Visual Sensations. — By far the most important sense is sight. We trust vision above the other senses in perception, and most people think in images. When we recall an object, we remember how it looks rather than any other of its sensory qualities. In discussing sight we have again to consider the three phases of the visual process, — external stimulus, sense-organ, and sensation. There is in vision rather greater dissimilarity between the different phases than in hearing. The physical stimulus is a vibration in the ~~hypothetical~~ ether. (V.! Note) The physicist tells us that the ether vibration varies in the same three ways as the sound

Note - Stimulus for light is waves in ether.

1. breadth or abundance.

vibration. Changes in rate or in length of the wave give quality, but only a small portion of the entire range affects the retina; changes in the amplitude of vibration give intensity; while changes in complexity give grays and colours of different degrees of saturation, — varying mixtures of grays with colours. The rate or length varies with the colour. Red has a wave-length of some 800–833 $\mu\ \mu$ (thousandths of thousandths of a millimeter), violet a wave-length of less than half, or 380–400 $\mu\ \mu$. The colours between have intermediate wave-lengths. Change in amplitude produces varying brightnesses, from black through the colours (what colour depends upon the wave-length of the light) to white. Mixtures of certain light-waves give white or gray, and of others give different spectral colours according to the wave-lengths that are mixed.

Note In any case it is evident that the qualities of the things as we see them are not at all like the vibrations which cause them. There is nothing in the colours to indicate that violet is a more rapid vibration than red. There are many disparities even in the relations. Red and violet are more unlike physically, but the sensations are more alike than those of red and yellow, or of red and any intermediate colour nearer red in vibration rate.

The Structure of the Eye. — The key to the difference between the physical stimulus and the qualities of colour must lie in the eye. That vibrations of different lengths give similar sensations must be due to the similarity of the physiological processes which they arouse in the retina. The eye can be best understood if it is compared to a camera. Three parts are essential to a camera: the box or container, the lens, and the sensitive plate. The box or frame of the eye is to be found in the sclerotic coat, the tough membrane

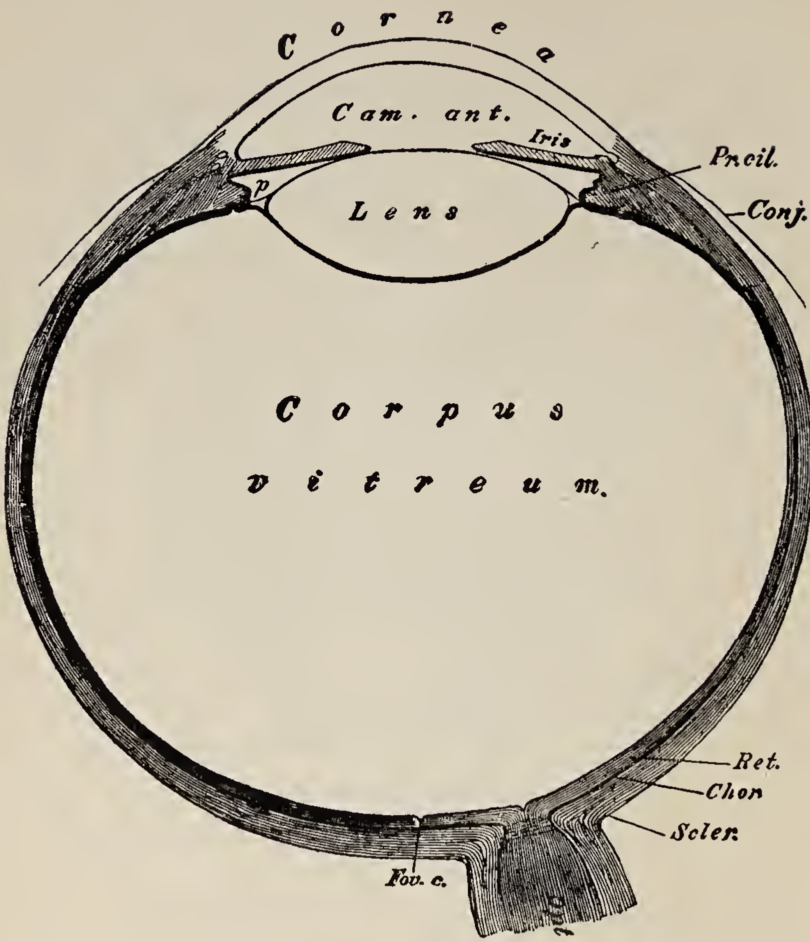

FIG. 21.— Section of eye. (*Scler.*) sclerotic coat; (*Chor.*) choroid; (*Ret.*) retina; (*Opt.*) optic nerve; (*Fov. c.*) fovea; (*Pr. cil.*) ciliary process, under it is the ciliary muscle which adjusts the lens for different distances; (*Conj.*) conjunctiva. (*Cam. ant.*) is the anterior chamber, filled with the aqueous humour; (*Corpus vitreum*) is the vitreous humour that fills the main body of the eye. (From Angell's *Psychology.*)

that holds the parts together, and is kept distended into a sphere by the pressure of the liquid within. The eye-ball is mounted in its socket, a conical hollow in the skull. It is held in its socket by threads of connective tissue and is turned by three pairs of muscles. Within the sclerotic coat is first the choroid coat which nourishes the eye and has some nerves and muscular fibers; within that is the retina which corresponds to the sensitive plate. The lens system of the eye is made up of two parts, the cornea and the crystalline lens. The cornea is really only a part of the sclerotic coat which projects slightly and forms in consequence a stronger lens. It is transparent instead of white and opaque as is the sclerotic coat. The lens is just back of the iris, the membrane which by its pigment gives the characteristic colour to the eye. It is attached to the choroid coat by a ligament, the suspensory ligament. That in turn is connected with the ciliary muscle which forms part of the choroid coat. In front of the lens lies the anterior chamber filled with a liquid much like water, as its name, aqueous humour, implies. Back of the lens is a large chamber, filled with the jellylike vitreous humour.

The Eye as an Optical Instrument. — The rays of light are bent at the front surface of the cornea, and at the two surfaces of the lens. The whole system has the same effect as if the light came through a single pinhole 15 mm. in front of the retina or 7 mm. back of the cornea. The size of the image of any object thrown upon the retina will be found by drawing a line from the sides of the object to the retina through this nodal point where the pinhole might be. One extremely important function of the lens is the accommodation or focusing of the eye. A camera that cannot be adjusted for different distances is of little value since it can

f - a.
t - n.

take pictures at one distance only. An eye with a fixed system of lenses could see objects at but one distance or only beyond a comparatively great distance. The eye is accommodated for different distances by changing the shape of the lens. The lens is relatively flat when one is looking at a distant object, but becomes thick and well rounded when one looks at a near object. This thickening of the lens may be seen if one will look across another's eye as he looks at objects at different distances. When the eye is adjusted for distance, the iris is flat; when it is focused on a finger held close, the iris is pushed forward by the lens. The shape of the lens is changed by the contraction of the ciliary muscle. When looking at a near object, the muscle contracts and permits the lens to take on its normal, rather round shape. When the muscle is relaxed, the lens is tightly stretched by the suspensory ligament and so becomes flatter and thinner. (See diagram.) Another adjustment of the eye that may be mentioned is the change in the size of the pupil. The iris is really a part of the choroid coat that might have been drawn away from the attachment to the cornea. It has two sets of muscles, one radial that pulls the pupil open, called the dilator muscles, another circular about the pupil called the sphincter. The pupil is the hole in the iris. When the eye is in the dark, the muscles that hold the pupil open are contracted; when the light is bright, the sphincter of the iris contracts, the other muscles relax, and the pupil becomes small. The dilation permits a larger amount of light to enter the eye, the contraction protects the eye against too bright light.

The real seeing portion of the eye is the retina. The retina is a part of the brain that has come to the surface in the course of development. It is made up of three layers

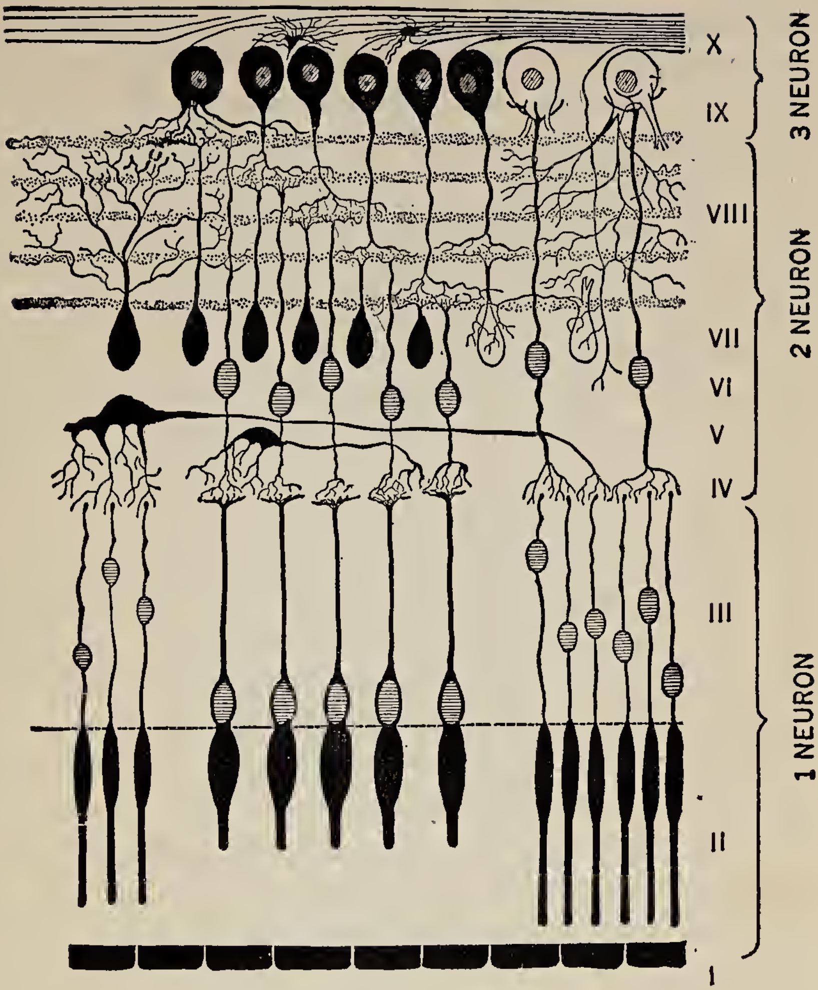

Fig. 22. — Schematic diagram of the finer structure of the retina. (I) is the layer of pigment cells; (II) the rods and cones; (VI) the bipolar cells; (IX) the large ganglion cells; and (X) the axones from the ganglion cells, which extend to the blind spot and there leave the eye and combine to form the optic nerve. The light enters the retina from the vitreous humour at X and passes through all the layers before it affects the rods and cones. (From Calkins *Psychology*, after Howell.)

of neurones. The structures that receive the light are the rods and cones. These are farthest away from the light, nearest the choroid coat. There is an intermediate and an inner neurone layer. The axones of the inner layer of so-called large ganglion cells combine to form the optic nerve. In exciting the eye a ray of light traverses the outer neurones as a physical impulse (vibration in the ether), strikes upon the rods and cones, is there transformed into a nervous impulse and transferred, first to the intermediate bipolar cells, then to the outermost large ganglion cells, and finally is carried back to the brain. Thus the nervous impulse goes back over part of the course that was traversed originally by the light-wave.

Fovea and Blind Spot. — At the center of the retina is a small depression or pit known as the fovea. In and about this the retina has a yellow pigment which gives the name, yellow spot, to the general region. Owing to the pit the light suffers less absorption than at other portions of the retina in reaching the sensitive structures. In the fovea there are only cones, and they are more closely set than elsewhere. The lack of absorption and the slight distance that separates the cones make the fovea the point of clearest vision. From the fovea outward the cones decrease in number until on the periphery they practically disappear. The entrance of the optic nerve is not provided with rods and cones and in consequence is not sensitive to light. It is what is known as the blind spot. We know, then, that the vibrations in the ether come to the rods and cones in the deepest coat of the retina. There in some way they are transformed into nerve impulses, pass from one to another of the three neurones in the eye, and then to the basal ganglia and cortex.

Know 3 main colour theories.

Vision a Photo-chemical Process. — The first question of function is how ether vibrations are changed to nerve impulses. An analogy for this is found in the action of light in producing chemical changes in the photographic plate. It is possible to observe directly changes of this kind in the visual purple found in the outer portions of the rods. This bleaches when exposed to light and becomes purple when the eye is kept in the dark. The bleaching of the visual purple has, however, only an indirect relation to seeing. The increased sensitiveness that comes after a long period in the dark is due to the effect of the visual purple, but ordinary daylight vision is practically unaffected by it.

Primary Colours and Their Combinations. — For an explanation of the action of the retina we are compelled to rely upon indirect evidence obtained by experiment and observation. At least three theories have been developed to explain the colour qualities. One theory, suggested by Helmholtz, would have but three primary colours and derive all others from them. The other two assume six primary single colours but do not agree entirely as to what they are. We shall follow, with certain modifications, the Hering theory, which assumes six fundamental qualities derived from opposed reactions of three organs.

The facts of colour vision which need to be explained are:

1. That all colours can be produced either by stimulating the retina with a single wave-length of light or by stimulating it by two or more wave-lengths. It is this fact which makes us believe that all colours can be explained as due to the stimulation of relatively few simple organs.

2. Each colour when mixed with a certain other colour produces white. This other colour is called its complement.

Complementary colours have no constant ratio of light-waves, but depend upon the physiological qualities. Red and blue-green are complementary, yellow and blue. Any mixed colour will have as its complement a mixture of the complements of the components. Yellow-green has a complement in a combination of blue and red or purple.

3. When a light-wave stimulates the retina, the colour is produced somewhat slowly and also dies away slowly. After the stimulation ceases, there is at first a persistence of the same colour, then the complement of the colour appears on the stimulated patch. This is known as the after-image.

4. About any colour there is found a rim of the complementary colour. This is known as the contrast colour. It explains why shadows on the yellow-green grass are purple, and shadows on the snow are blue, the complement of the yellow of sunlight.

5. Some individuals may be defective in seeing certain colours and see others perfectly. The most common defect is for red and green. Certain people cannot discriminate red from green. Others are blind to all colours and cannot discriminate between any two of the colours, except by brightness. Both conditions are known as colour-blindness, the first partial, the other total.

6. The normal adult individual has two organs for vision, the rods which are affected by faint lights, and give only NB sensations of gray, and the cones, which are used in bright lights and give sensations of colour and probably also sensations of gray. The rods are more sensitive to the short wave-lengths of light and in consequence see red as black and the blues as brighter grays. While the bright spot in the spectrum seen at ordinary brightness is in the yellow,

when seen at low intensities corresponding to twilight, the brightest spot is in the yellow-green or green. The totally colour-blind individual has the twilight values. Of the partially colour-blind some see the brightnesses as we do in twilight and others as we do in daylight.

Various theories have been developed to explain just what the definite mechanism may be that makes possible these facts. All agree that we must assume that there are relatively few simple organs or processes in the retina which produce the effects. These simplest substances or processes are assumed to be three by Helmholtz, to be six by Hering and Mrs. Ladd-Franklin. The colours which correspond to the simple processes are called the primary colours. When two of these are stimulated composite effects are produced. Many of the effects, especially after-images and contrast colours, are due to processes originating within the retina rather than to the light-waves. The facts themselves may be elaborated in connection with the theories.

The Hering Theory. — The Hering theory assumes that there are six processes connected in pairs with three organs. The processes are the colours red and green, blue and yellow, and black and white. He assumes that each of these organs responds in opposed ways. The red-green organ gives red when excited and green in the process of recovery; similarly the blue-yellow organ, yellow when excited and blue in recovery. White is the response to stimulus, and black the recovery in the black-white organ. This organ responds indifferently to all wave-lengths.

The spectral qualities and purple are obtained from the four primary colours. Orange is a combination of red and yellow and may be produced by combining red and yellow lights in the right proportions. When a spectrally pure

ray of orange light falls upon the retina, it excites the two responses red and yellow in different degrees, and the results of the two physiological processes combine in the brain or in consciousness to produce the single sensation of orange. Similarly, yellow and green combine to produce canary yellow, green and blue to give robin's egg blue and other shades. Finally the circle is completed by the fact that red combines with blue to give first indigo, then violet and the whole series of purples that fill the gap between the ends of the spectrum. It is interesting to note that, while all the other mixed colours may be produced either by having a single pure light-wave fall upon the retina or by combining two lights in proper proportions, the purples can be induced only by combining lights. There is no single ether-wave that gives a purple colour. Nevertheless, purple is quite as unitary in sensation as any of the colours due to a single wave-length.

omit

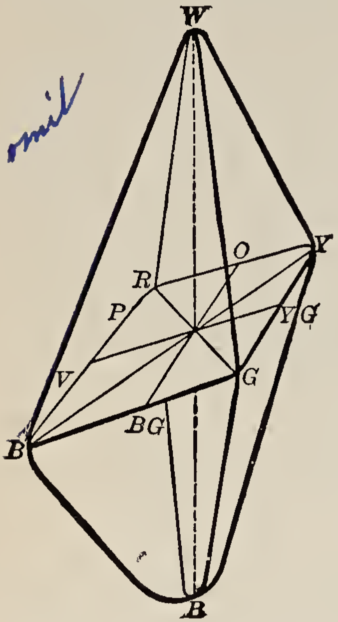

FIG. 23. — Represents schematically the relation between light-wave and colours. The line *BW* indicates changes in intensity of stimulus from zero to maximum. The central square shows the colours which are produced by the wave-lengths. (*B*) is blue; (*V*) violet; (*P*) purple; (*R*) red; (*O*) orange; (*Y*) yellow; (*YG*) yellow-green; (*G*) green; and (*BG*) blue-green. (From Titchener, *Textbook of Psychology*.)

The relation of the spectral colours to the simple colours may be illustrated by a square. (See diagram, Fig. 23.) The corners represent the simple colours, the sides the combinations that may be

produced from them. With each of these colours a brightness is combined. These series of brightnesses extend from black to white. All wave-lengths excite the brightnesses, and the quality of the brightness depends upon the amplitude of the wave, not at all upon the length. Each of the waves at a certain moderate intensity excites brightness in very slight degree, colour in larger amount. This is the pure spectral colour. A faint red light appears black because it affects the brightness organ only; as it grows brighter it becomes first dark brown, then dark red, then red, then bright red and pink, and with very great intensities approaches white. Where the colour is present in greatest proportion, it is said to be saturated. As the gray becomes more and more prominent, the colour is said to be less and less saturated. These degrees of saturation are represented by the radiating lines on the square of the colour pyramid.

Complementary Colours. — One result of mixing colours, the phenomenon of complementary colours, is particularly important for theory. When colours at opposite corners of our colour square are mixed in suitable proportions, they give, not an intermediate colour, but brightness. Each colour in the spectrum has its complement which when mixed with it gives white. Apparently the complementary colours produce exactly opposite effects upon the substance sensitive to them: each destroys the effect of the other. When they thus neutralize each other, the only effect is to excite the organ of brightness, and the result is white, gray, or black, according to the intensity of the colours. When any two colours are mixed, there is always partial cancellation, and the resulting colours are always less saturated than the components would be. If all the colours of the

sun's rays are mixed, the components all cancel each other and the result is the white or slightly yellowish daylight. We may represent the grays upon our diagram by a line *BW* through the center of the square extending above and below. The fact that each light ray at a slight intensity excites only gray or black may be indicated by connecting each corner of the square with the ends of the line. It seems probable, too, that the lights in maximum intensity excite only the brightness organ. This is represented by connecting each corner of the square with the top of the brightness line as well. Thus drawn, every point on the pyramid inside and out represents some colour or shade, and all visual qualities are represented.

After-Images. — Hering argues that the fact of complementariness makes it probable that the colour qualities of each pair have their seat in a single organ. This assumption is furthered by other facts of vision. Thus if one looks at any colour or any brightness for a few seconds and then looks at another surface, the complementary colour will be seen. Red gives an after-image of green, yellow an after-image of blue, and *vice versa.* It is assumed that the after-image is due to the fact that when the organ is excited in one way, recovery from the excitation evokes the complementary colour.

Colour-Blindness. — Even stronger evidence for assigning each pair to a single organ is derived from the phenomenon of colour-blindness and the distribution of the colours upon the retina. Hering insists that partially colour-blind individuals lack altogether the red and green components of colour, and none are found who can be shown to be altogether lacking in one alone. If one is colour-blind, it is either to red and to green or to all colours, never to red or

to green alone. Approximately three per cent of the male population is colour-blind in sufficient degree to be uncertain in the discrimination of red from green. Since for some reason the railway and navigation authorities hit upon these two colours for their signals, it is essential that all colour-blind men be excluded from their employ, hence the careful examination to which they subject applicants for work. The phenomena of colour-blindness are present in every normal eye. In a band about the center red and green cannot be seen. Beyond this band the eye is totally colour-blind: only black and white are appreciated there. This outer colour-blindness may be demonstrated by moving a small bit of paper of some colour out toward the periphery of the field of vision while the eye is kept fixed upon a point. If the colour be primary, it will turn to gray when it changes at all in quality. If it be a composite colour like orange, it will change first to yellow and then, when it gets beyond the blue-yellow zone, to gray.

Colour Contrast. — One other phenomenon related to complementariness and after-images is contrast. If two complementary colours are placed side by side, each becomes brighter because of the presence of the other. If a colour is seen against a gray background, it will be surrounded by a fringe of the complementary colour. Red will give a green, blue a yellow, and so on. The contrast effect may be observed if a small patch of gray paper be placed upon a coloured surface. The effect will be increased if a bit of translucent paper be put over the colour and the square of gray. Contrast colours are also very clearly seen when a shadow is thrown upon a coloured field, as when two shadows of the same object are cast by different coloured lights. The explanation of contrast is said by Hering to

be found in the opposition between the chemical processes excited by complementary colours. When a surface is stimulated by one light, the opposite process is induced in the surrounding areas of the retina.

The Colourless Visual Sensations. — Whenever light which does not affect the colour processes stimulates the retina, brightness or black-white sensations result. All light affects the black-white organ, but when the colour processes are also stimulated they are appreciated only as they make the colour brighter or darker or reduce its saturation. Brightness alone is appreciated, as has been seen, when complementary colours cancel each other; in the eyes of the totally colour-blind and on the periphery of the normal eye; when the lights are too faint to excite the colour processes; and when the coloured objects are very small or the stimulus has a very short duration. In the dark all colours become grays of different shades. Very small patches of colour are also gray. A coloured object at a great distance becomes a gray of a brightness that corresponds to the intensity of the light. It is for this reason that very brilliant colours may be used in the uniforms of troops. When seen from a distance these stimulate a very small patch on the retina, and if they are of the brightness of the surrounding natural objects will not be observed. The light blue of the French uniforms, the khaki of the British and American troops, and the light gray of the German are equally difficult to detect at a distance. When different colours of slight extent are interspersed or larger patches side by side are seen from a great distance, they combine just as when mixed by rotation. Thus the small bits in a mosaic, or the different coloured threads in worsted combine to produce uniform shades.

Hering - red & green, blue & yellow; black & white
Helmholtz - red, green and violet.

The Helmholtz theory differs from the Hering in assuming but three primary colours in all and deriving all colours from these three. The three are red, green, and violet. Yellow is said to be made by simultaneous stimulation of red and green and is not a separate colour process as it is for Hering. The three colours when excited together in the same amount produce white, and there is no independent organ for brightness according to Helmholtz. Negative after-images are explained as due to the fatigue of the colour organ stimulated. When a white surface is looked at the two unfatigued organs are stimulated which produces the complementary colour. Contrast was said to be an illusion of judgment and to have no corresponding retinal process.

Note

Helmholtz asserted that either the red or the green organ could be wanting and that there was thus red blindness and green blindness as well as a combination of the two. This point is still in controversy. If settled it would provide a criterion for deciding between the two theories.

Mrs. Ladd-Franklin developed a theory that is in many ways a compromise between the two others and also adds an evolutionary explanation. She believes with Hering in an independent yellow and white. She assumes that the rods are the primitive organs and that the cones develop from them. The primitive eye where rods alone have developed sees only white and grays. The rod undergoes a development of substances sensitive to blue and yellow. When this organ has differentiated it will, when stimulated by white light or by blue and yellow, respond with the primary sensation white. Then later the yellow substance differentiates into two organs, one sensitive to red, the other to green. This also gives the original sensation yellow when stimulated at the same time by both red and

green. Red-green colour-blind eyes are those which have only reached the stage at which the blue-yellow substance has developed, or in the totally colour-blind have stopped with the rod as the only organ.

A series of recent discoveries emphasize the importance of the presence of both rods and cones in the retina. These indicate that the rods give impressions of brightness alone while the cones are responsible for the sensations of colour. One striking fact that bears this out is that certain individuals are totally colour-blind and that these individuals are totally blind in the fovea, the portion of the retina most sensitive in the normal eye. The totally colour-blind individual is very keen in seeing in the dark and is oversensitive to bright light. The normal eye is assumed to see with the rods in the dark and to use the cones only in the bright light. The rods alone have the visual purple which is assumed to make possible the increased sensitivity that comes after a period in the dark. The purple is regenerated in the dark, a process which requires approximately an hour to be completed, and during all of this time the eye becomes more sensitive to faint lights. When the adaptation is completed, the eye is approximately one thousand times as sensitive as at the beginning.

Another fact that marks the rod vision as different from the cone is that the rods are more sensitive to the short wave-lengths, the cones to long wave-lengths. If one looks at the spectrum of great brightness the brightest colour is the yellow-green. If one looks at a faint spectrum in the dark after a period of adaptation, it seems to be only a band of gray. Where the red was at the ordinary brightness now appears quite black, and the brightest point has shifted to the green. The totally colour-blind man always sees

the spectrum as we see it in the dark. It is always merely gray, the reds are black and the greens are a considerably brighter gray. Differences between the red-green types of colour-blindness can also be detected in this respect. One is more like the totally colour-blind in seeing greens as brighter; the other is like the normal eye in seeing red and yellow as brighter. These facts together are accepted as sufficient to prove that rods and cones have different functions. The rods are used in faint light and give only sensations of gray. The cones act in moderate and bright light and give rise to the sensations of colour as well as of gray.

Summary of Vision. — In brief we may assume that there are no more than six processes in the retina from which all of the visual qualities are compounded. These six qualities are grouped in pairs, red and green, blue and yellow, and black and white, and each pair finds physiological explanation in opposed processes in the same substance. When the two processes are equally excited simultaneously, there is no effect upon the colour organ, but only the resulting effect upon the brightness organ. When one process has been aroused, its opposite succeeds it after a brief persistence of the first. In colour-blindness the red-green organ is most often lacking, the yellow-blue organ is very seldom lacking, while the black-white organ is always present unless the eye be totally blind. It is interesting to note that the manifold wave-lengths in ether affect the retina in but six different ways. However, what is lost in complexity in the retina is got back with interest in consciousness. The six processes by their combinations give rise to from thirty to fifty thousand distinguishable qualities. It is interesting to note that the physiologically

complex colours are little if any less simple as conscious qualities than the simple physiological colours. So true is this that just what the simple physiological qualities are is still a matter of dispute. Each colour theory has a different set of primary colours and the only hope of agreement depends, not upon introspective analysis, but upon physiological experiment.

Kinæsthetic Sensations. — In addition to the traditional five senses of man, many new sense qualities and sense-organs have been discovered relatively recently. Most important of these is the sensation complex that tells us of the movement of the body, of weight, and resistance. When one moves the hand, one knows at once the amount and direction of the movement even with the eyes closed. Movement is known by the kinæsthetic sensations. Pathological cases are found, however, in which the patient is unconscious of movement and of weight. When he moves, he has no idea that he has moved, and he has no idea of the position of his members when they are at rest. These cases emphasize the fact that the normal man must have some special sense-organ for the detection of movements. Investigation has shown that the sensations come from organs in the muscles and tendons. Patients who cannot appreciate their own movements lack the nerve paths over which kinæsthetic impulses should travel to the brain from these organs. In the tissue of muscles and tendons are sense-organs not unlike some of the organs found in the skin. When the muscle is contracted, the cells of the muscle become shorter and thicker. This change exerts pressure upon and stimulates the sensory nerve-ends between the muscle cells. For example, whenever the arm is moved, there is a contraction in one set of muscles and a

relaxation in the opposing set. In one set of muscles the sense-organs will be compressed, in the other set the pressure will be relaxed. Each movement and each position has a complex of increasing and decreasing stimulations which is characteristic for that movement in quality and intensity. Strains and weights when the arm is not moved reveal themselves in similar pressure exerted upon the sense-organs of the tendons in addition to that upon the muscle-organs. It is by these organs that we become aware of the fundamental physical properties of the world, — of motion, of energy, and of mass.

The Static Sense. — One of the most interesting of the recently discovered sense-organs is the organ of the static sense found in the semicircular canals and neighbouring organs of the ear. Hairs project into the liquid of the semicircular canals. When the liquid is disturbed by the motion of the body, the hairs are moved and they in turn excite the nerves connected with them. These impulses are transmitted to the motor neurones which control the movement of the body, and movements are made which adjust the members to the new position or bring the body back to the upright. When the organs of the labyrinth inner ear are injured, proper motor adjustments are difficult or impossible. An animal with injured semicircular canals will not be able to stand, or at least to stand steady. When the organs are lacking in man, reflex eye-movements are wanting. It is, perhaps, a question whether the static sense is a real sense, for we become aware of its action only indirectly through the movements it induces or, when the excitation is more intense, by the disturbances of the alimentary tract that give rise to the sensation of giddiness. When still more intense, the stimuli from these organs call out the more

active phenomenon of vomiting involved in seasickness. (What the immediate quality of the sensation from the static sense may be, if there is any, is not known.) Note

Organic Sensations. — Many other sense-organs and sense qualities are found in the organs of the trunk. The sensations from them have not been satisfactorily analyzed, and their organs are not well known from physiological experiments. We ordinarily group them into a single mass of organic sensation. Of these, the pangs of hunger have been shown recently to be due to the reflex contraction of the walls of the stomach. Thirst has its seat in the upper throat or back of the mouth. It is probable that there are special organs that inform us of circulatory disturbances, of the respiratory processes, and of many others less well distinguished. One is aware of feeling well or feeling ill, and if one will examine the experience more closely, vague sensory qualities may be analyzed from the mass. It is to be hoped that these complexes of organic sensation may some day be broken up and their sense-organs determined. Until that time we can merely refer to the mass.

Summary of Sense Qualities. — If we sum up the results of this discussion of the qualities of sensation, we find that there are relatively few simple qualities received from sense-organs and, regarded from the physiological side, relatively few sorts of sense endings. A table will show the number of qualities from each sense.

Qualities from the skin	4
Qualities of taste	4
Qualities of smell	uncertain (6?)
Qualities of hearing	uncertain (11,000?)
Qualities of sight	6 or 4
Qualities of kinæsthetic sensations	1 or 2
Qualities of organic sensations	10 or 12 (?)

N.B. In all there are but forty or fifty different sorts of nerve ends from which all the varieties of our conscious qualities are derived. We might obtain a much larger total if we considered the number of qualities that could be recognized by unaided observation as distinct in consciousness. Then we should have 11,000 tones, some 40,000 colour qualities, unlimited tactual qualities, the different complexes of taste and smell, one for each distinguishable substance, — to say nothing of the vast number of organic complexes that change with each of our moods, and with our condition of health. Enumeration on this basis has never been attempted except for sight and sound, but it is probable that the other senses give similar large numbers of sensations or complexes of sensations.

Intensities of Sensation. — One other aspect or attribute of sensation, important in practice, is intensity. The intensity of sensation is dependent upon the intensity of the stimulus. The more energy acts upon the sense-organ, the greater the intensity. Note While intensities are very important in our life, they are not easily described or even thought of in absolute terms. They cannot be easily remembered. We have no accurate names for the degrees of intensity in our non-scientific vocabulary. Pounds and kilograms, ergs and horse-power, are obviously artificial units and correspond to nothing that we can picture easily. For everyday usage slight, moderate, and intense are the only terms available to designate intensities. The difficulty in description and discussion is all the more marked because experiments show that there is no direct relation between the intensity of the physical stimulus and the resulting consciousness. As nearly as one can make out, a thousand ounces do not give a thousand times as much weight sensa-

tion as one ounce. Sensations seem to increase in amount very much more slowly than stimuli increase in intensity, — if one may speak of the amount of sensation at all. Intensities of sensation cannot be described by words as we describe qualities of sensation, and they cannot be measured by measuring the intensity of the physical stimulus and assuming that the sensation will harmonize with that. Both the simple methods of approach fail us.

Note

Weber's Law. — The attempt to discover some means of dealing with the intensities of sensation led indirectly to the establishment of a law of relation between stimulus and sensation which is known from the name of the man who first noticed the relation as Weber's law. This asserts that the least addition to a stimulus which can be noticed is always a constant fraction of the original stimulus. Thus in lifting weights one can distinguish between an ounce and an ounce and a fortieth. But if a pound be the standard, one cannot notice the addition of a fortieth of an ounce; a fortieth of a pound must be added. In any sense-department it has been found that an addition to be just noticed must be some fraction of the stimulus present, rather than an absolute amount. The fraction that must be added is different for each sense. It varies from about one one-hundredth for sight to about one-third or one-fourth for smell. Several different formulæ have been used to express the relation. Perhaps the best known and the simplest is that sensations increase in arithmetical ratio, as stimuli increase in geometrical ratio. The stimulus must always be multiplied by some fraction, — for passive pressure, *e.g.* by four-thirds ($\frac{4}{3}$) — to obtain the next unit of sensation.

N.B.

Deviations from Weber's Law. — The most obvious outcome of the law in everyday life is that only relative

differences can be appreciated. One is aware of the relative difference in brightness between the black of the print and the white of the page, but is not aware of the absolute change in the brightness of each between noon and evening. Were the law to hold absolutely, the light might fade and we be unaware of it. The fraction that can be noticed is not absolutely constant, however, but holds only for the middle ranges of intensity. As the light grows dim, the just distinguishable differences must increase, until in the later twilight white must be more than sixty times as bright as black to be readily noticed as different from it. We know this because we cannot read in the faint light although the white of the page is approximately sixty times as bright as the black of the letters. Similarly, as the absolute brightness is increased, the fraction increases or, put the other way, the relative sensitivity decreases. Slight differences are not so easily noticed in the full glare of the sun as in diffuse daylight. One cannot read ordinary print at night or with ease in the glare of the noonday sun.

The Sensation Threshold. — Not only may differences between intensities be too slight to be noticed, but stimuli may be too faint to give rise to any sensation whatever. As one moves a watch away from the ear, the sound becomes fainter and fainter until it finally disappears. One may touch a pressure spot on the skin with a hair so soft that it gives no sensation. The intensity that can be barely noticed, that first gives rise to a sensation, is called the liminal or threshold stimulus. At the other extreme it is probable that a stimulus may be too intense to be felt. Probably, however, intensities which do not destroy the sense-organ merely tend to be lost in the accompanying pain; they do not actually disappear. The upper limen is

of relatively little importance, and there is little known about it because of the injury which work upon it might do to the sense-organ.

QUESTIONS

1. What is a sensation? Is it a physiological or psychological process?

2. What determines the quality of a sensation? Does it depend more upon the stimulus or upon the organ stimulated? Is there sound when there is no ear to hear?

3. What is the physiological zero point? Is it always the same? Is it the same for the exposed hand and for the elbow which has just been uncovered?

4. What elementary sensations are excited when the hand is put into water at 48° C.? at 10° C.? What is the paradoxical cold sensation?

5. Name the components of the 'taste' of ice cream; of hot coffee; of pepper.

6. Describe the action of the three small bones of the ear during hearing.

7. Is the basilar membrane broader near the oval window or near the apex of the cochlea?

8. What is a noise: (*a*) physically? (*b*) physiologically?

9. What is an octave? an overtone? How are the C of the violin and of the piano different?

10. State the Helmholtz theory of hearing. What facts tend to prove it; what to disprove it?

11. Are the ganglion cells or the rods and cones nearer the vitreous humour? nearer the pupil?

12. Why is vision clearest at the fovea?

13. Describe the different forms of colour-blindness. What sensation does the colour-blind man receive from a primary red? from orange?

14. Under what circumstances does the normal eye see gray? What different organs are excited when we see gray?

15. What is the visual purple? Where is it and what is its function?

16. How does seeing the stars at night and not during the day illustrate Weber's law?

17. What is meant by the sensation or absolute limen? the difference limen?

EXERCISES

1. Mark off an area on the skin a centimeter square. Touch each point of the area with a pointed metal rod warmed to about 40° C. Mark the spots where warmth is felt. Repeat with the rod cooled by immersion in ice-water. Mark the points where cold is felt. Compare with the warm spots. Are they the same? Stimulate a definite cold spot with a rod heated to about 55° C. What stimulus do you receive? Why?

2. Press gently upon the different regions of the same area with a pointed toothpick or human hair. Mark the points where pressure is felt. Go over the same area with a sharpened horsehair fastened by wax to a handle. Note the points where pain is felt. Compare with pressure and with the temperature spots. Can you make out any law of arrangement?

3. Observe in a glass the red openings of the papillæ on the end of the tongue. Mark five papillæ on a drawing of the tongue. With a brush stimulate each papilla successively with a solution of salt, sugar, vinegar, and quinine. Are all of the spots sensitive to each substance? How can you explain the results by the doctrine of specific energies?

4. Fatigue the nostril for camphor by smelling a lump of the gum until it is no longer perceived. Try the nose for iodine. Fatigue again for camphor and try for vanilla. Test in the same way for rubber, asafœtida and other substances. What do the results prove of the nature of olfactory qualities?

5. Draw the ear to demonstrate the relations of the bones of the middle ear to the cochlea and the auditory nerve.

6. Demonstrate the presence of overtones in a note of the piano. Strike the lowest C while the key that gives the octave is held down. As the first key is dropped you will hear the octave still resounding by sympathetic action induced by the first overtone of the fundamental. Proceed in the same way to determine what other overtones are present in the note first struck. How do these overtones affect the ear?

7. Mix blue and yellow in different combinations on a rotating colour-mixer. If this be not at hand, a substitute may be prepared as follows: Place a square of yellow paper and a square of blue paper of the same size a foot apart upon a black cloth on a table. Hold a pane of clear glass vertical midway between them and look through the glass at one, and adjust the second square so that its reflected image covers the first. When the two colours are brought to coincide the apparatus makes a simple colour mixer. The intensities of the colours may be varied by turning the glass plate about the line of contact with the table. What colour does the mixture of blue and yellow give rise to when the apparatus is adjusted to give equal amounts of each? Try mixtures of other primary colours to give the list of spectral colours.

8. Place a bit of green paper over a dot on a sheet of gray paper. Look intently at the green paper for ten seconds. Then blow the green bit away and look for three seconds or so at the dot. What colour replaces the green? Repeat with the other colours and record results.

9. Place a centimeter square of gray paper on a large square of red. Cover both with tissue or other translucent paper. Note the colour of the small square as seen through the tissue paper. What gives it a colour? Test on surfaces of other colours. What is the general law?

10. Look steadily with one eye at a point on a wall, preferably a gray wall. Have an assistant move centimeter squares of coloured paper away from the fixation point. Note the point where the different colours disappear or change. Measure the distance from the fixation point in different directions. Compare the distances for different colours. Can you interpret the results by the phenomena of colour-blindness mentioned in the text?

11. Draw the eye showing the lens system and its relation to the iris, retina, and various coats. On a larger scale draw a portion of the retina that shall indicate the nervous connections between the rods and cones and the fibres of the optic nerve.

12. Bend the finger at the second joint. Can you detect deeper lying sensations? Can you distinguish them in quality from the pressure sensations? What is the sense-organ that gives rise to them?

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CHAPTER IV

THE NATIVE AND THE ACQUIRED FACTORS IN BEHAVIOUR

The animal or man comes into the world with a nervous system ready for action and with sense-organs prepared to receive stimuli from the world about. The neural currents initiated by these stimuli are distributed through the mass of neurones to the muscles, which by their contractions cause all of the movements of the body. The behaviour of the animal is to be regarded as the result of the excitations and of the way the resulting nerve impulses irradiate through the mass of neurones which compose the nervous system. Certain of the responses, such as the nursing movements in the child, are due to connections in the nervous system prepared at birth; others such as playing the piano, are acquired through practice almost entirely, and others, such as the pecking in chicks, may be partly ready at birth, and are partly learned on the basis of that preparation. To understand any action we must study the actual movements and refer them to what we know of the nervous system. We may begin with the nature of the mechanism involved so far as it is known directly or inferred from the experimental results.

The Mechanism of Learned and Instinctive Movements. — Present-day neurology pictures the nervous system as a mass of independent living cells, the neurones, and of action as determined in its character by the paths which develop

through the neurones. The neurones are always ready to act when any stimulus reaches them. The neurones connected with the sense-organs are set in action whenever a stimulus is applied to the sense-organ. This arouses an impulse which passes at once to the end-brushes of the neurone. Another neurone is found at the end of each end-brush with its dendrites almost or quite in contact. If the impulse spreads to one of these dendrites one movement will be made, for that neurone leads to others which finally connect with one group of muscles. If it spreads to another dendrite some other movement will be made. Which movement will be made depends upon the gap between end-brush and dendrite that is crossed. The readiness of passing from neurone to neurone across these gaps is regarded as the final determinant of all action. This fact makes it very clear that we should understand what this gap is and obtain an idea of the theories which have been developed as to the way the gap may be bridged. The gap itself is called the synapse.

Neural Impulse and the Function of the Synapse. — To appreciate the problem we must recall that a nerve impulse is assumed to be a combination of electrical and chemical processes. A chemical process is excited by the sense-organ. This arouses an electrical current which passes along the nerve for a short distance only and then initiates a new chemical reaction. This starts a new electrical current and so on. When the end-brush of the first neurone is reached either an electrical or chemical process or both must cross to the dendrite of the next neurone if that is to be excited. We are still in the speculative stage of development of our knowledge as to what passes and how. The end-brush and the dendrite both are assumed to have a

note.

membrane which retains the protoplasm of the neurone. Certain theories assume that the two membranes are always in contact and so that the structure of the membrane is the determining factor. Others have assumed that there is a space between the membranes originally and that this may be bridged in some way, so that either an electric current or chemical substances could pass from one neurone to the other. The different theories depend upon the assumptions made on this point and as to whether what passes is chemical or electrical in nature.

FIG. 24. — A neurone (*B*), with many synapses, (*a*) and elsewhere, from the cerebellum of a rat. (After Cajal.)

Spatial Theories of the Synapse. — One early and one recent theory make the openness of the synapse depend upon whether there is or is not physical contact between end-brush and dendrite. (An early theory assumed that the neurones still retained the capacity of the amœba and other single-celled animals of extending their processes, (and that the dendrites might be extended on occasion to make contact with the end-brush and might at other times be withdrawn.)) This was picturesque, and as evidence to Note

prove it was cited the observation that animals killed by an anæsthetic seemed to have the dendrites shorter than normal. It was assumed that the unconsciousness of the anæsthetic was caused by breaking the connections between neurones. The theory did not cover several points that were important. Since the dendrites are on the receiving neurone, those away from the sense-organ, they could not be put out in response to stimulation. The changes that come through learning would assume some permanent change in the habits of the neurone in putting out its dendrites, which do not readily fit into the facts. A later suggestion by Kappers is that as a result of the electrical currents accompanying nervous action neural filaments might be made to grow across the gap. This does not harmonize with the fact that learning is relatively quick, while growth of the filaments would require considerable time. Then, too, it would not permit forgetting.

The Sherrington Theory. — Sherrington emphasized the chemical nature of the nervous impulse and assumed that the membranes of dendrite and end-brush are always in contact. On that assumption passage of chemical products or constituents of the reactions involved in nerve action would spread through the membranes and initiate the activity in the neurone across the synapse. The passage was asserted to be due to osmosis across the membranes and whether it passed or not would depend upon the permeability of the membranes. Sherrington assumes that passage of chemical substances through the membrane would reduce its original resistance. This would explain learning. It is sufficiently indefinite to be open to no great objections, and if true would agree with the known facts of nervous action.

emphasized chemical nature.

Electrical Theories of the Synapse. — Others have suggested that what crosses the synapse is the electric current which accompanies the nerve action. One theory suggests that excitation depends upon the electrical tuning of the two neurones, that when they tend to respond at the same rate, one will readily excite the other, while when they have different rates the impulse will not pass. It is similar to tuning in on different wave-lengths with the radio. This theory explains the native differences, but has not been adapted to the phenomenon of learning. Taken as a whole, the theories are of value in stating the problem, rather than in solving it. We can be assured only that the original tendencies to action are due to the synapses which are open at birth, that these determine the first movements which we know as the reflexes. It is possible through use to make actual the passage of impulses along paths which were only potentially open at birth. This explains the phenomena of learning, which is one of the most important, if not the most important, factor in all action of man as well as of the animal. While it is interesting to speculate about how these changes take place in the nervous system and what they are in themselves, they at present merely emphasize the fact that certain acts are determined at birth, by the constitution of the nervous system, and that the individual does change these capacities as a result of experience.

The explanation of all action is found directly in the passage of impulses through the paths formed from neurone to neurone in the nervous system. The movements of an adult would be determined in part by the synapses that were open at birth through inherited connections, and in part by those that have been developed through use during the life of the individual. Those open at birth are assumed

N. B. to make possible the very simple, almost machinelike movements which we call reflexes, those that have been opened through use make possible habits. All authorities would grant that both these groups exist. Much controversy has arisen recently as to whether there exists a third group of activities which are nearly as complicated as the habits and which are nevertheless like reflexes due to the inherited connections at the synapses. These, if they exist, would be called instincts. They would explain the movements of locomotion, the nest building activities of insects and birds, and many others in animals and at least a few in man. Until recently it was generally assumed that both man and animals were determined in many complex activities by these innate tendencies to movement. Recently, however, many have questioned their existence and we must examine the facts to determine whether they are present and if present what they contribute to the action.

Variability of Response Due to Overflow. —A fact of nervous action important in explaining any action is that in even the most rigidly determined movements there is always a certain amount of indefinite or misdirected discharge of nerve impulses. Whenever a stimulus is applied to an animal, even a new-born animal, a series of movements always results. If it evokes a definite response, we call it a reflex. If not, we have diffuse movements. When a stimulus is applied which ordinarily evokes a reflex, but which is stronger than is required for that reflex, we note that in addition to the reflex proper many other movements are aroused in the neighbouring or even in remote groups of muscles. Throw a bright light in the eye of an infant or adult and one sees not merely closing of the lids, change in the size of the pupil, etc., but also movements of the eye-

brows, and even general squirming. (As neural processes these are to be explained as the results of a spread of the impulse aroused by the stimulus to many different motor paths.) If there is no specific synapse over which the sensori-motor nerve current will flow, one or more synapses will open and the corresponding motor neurones and muscles will be reached. These diffuse movements result. (When there is a specific path, an unusually strong stimulus will overflow into other paths and produce these excess movements.) It is these overflowings to new paths which make possible learning. For a movement that is not natively determined by open synapses may, by repetition, have the corresponding synapses open until it follows the stimulus almost as certainly as does a reflex. (It also frequently happens that a movement which occurs first as an overflow effect of a reflex or an already established habit may be repeated until it develops into the normal response to that stimulus.) This is the physiological basis of all acquisition of new movements.

The Forms of Behaviour. — We have outlined the neural facts fundamental to all behaviour, and must now turn to the concrete activities of the organism. The activities of any animal or man may be regarded as compounded of the effects of tendencies to movement determined by these open synapses. The problem is to unravel the complex and relate it to the different elements. The different types of movement may be defined and then related to the specific actual cases of action as we see them.

The Unlearned Responses to Stimuli. — We must begin any discussion of action with the tendencies to respond that may be assumed to be present in the animal in advance of any learning. The primary forms of action of simple

unicellular animals are mere avoiding or approaching reactions which have been called tropisms or taxes. Some of the simple organisms will always approach a light of a certain intensity and others will move away from it. These movements were regarded by Loeb as analogous to the turning of plants or their parts away from or towards the light, and were ascribed by him to the direct effect of the light upon the tissues. The light might make the part of the cell towards it contract and so turn the animal until it was headed directly towards or away from the source of light and its natural processes of locomotion would drive it to the light or away from it. The movement towards the light was called positive heliotropism, the movement away was called negative heliotropism. Verworn used the term phototaxis in place of heliotropism.

Similar responses were recognized to heat, thermotaxis, or thermotropism; to contact with solid objects, stereotropism; to the motion of water, rheotropism; to gravitation, geotaxis, etc. In each of these the stimulus was assumed to act directly upon the structure of the cell or cells, and to produce a mechanical or chemical change that resulted in the movement. The exact mechanism of the response is not so clearly made out as for light in certain of the cases but is supposed to be analogous. Thus some of the primitive forms show a tendency to rise to the surface of the water in dark as well as in light, and this is explained as a negative reaction to gravitation which induces the upward locomotion. Certain fish always swim up-stream, or will swim up-stream when heavy with eggs. In one case it was shown that this swimming against the current was a visual reaction to the bottom of the stream, although one might have believed it to be due to the stimulation of the

surface of the body by the running water. Moving a broad strip of paper painted with cross bars below the glass bottom of an aquarium caused the fish to move in a direction opposed to the motion of the paper. Our present object is not to seek an explanation, but to indicate that there are tendencies to respond inherent in the tissue itself that determine how the first responses of the animal shall be directed. They enter into the determination of the activity of the animal, and possibly may in some cases have an influence upon the responses of the infant.

Reflexes and Instincts. — Reflexes are admitted by all to be present in the infant and new-born animal, although there may be some difference of opinion as to how many and what they are. The problem of instinct offers much difficulty. A generation ago the general opinion was that all animals and even man had a very large number of instincts. Instinct was then defined as a fully formed tendency to make relatively complicated groups of movement that was present at birth or without previous trial. In the last decade this assumption has been vigorously questioned. While the earlier men were inclined to regard as an instinct every movement which could not be proved to have been learned, the present tendency is to say that all is learned unless it can be definitely shown to be present at birth. Much of this skepticism rests upon an experimental basis. Experiments show that the pecking of chicks, for example, is uncertain in the newly hatched although it attains relative perfection in a few days. The nursing movements in the babe improve with practice. Kittens must learn to kill mice. Where Fabre, the French naturalist who wrote in the last century, believed that a certain wasp stung caterpillars in the nerve centers so as to paralyze but not kill them,

the Peckhams discovered that the stinging was relatively inaccurate. Sometimes they were killed and at others they chanced to be merely paralyzed. We must then seek an agreement as to what an instinct is before we can discuss it.

Possible Instinctive Characteristics. — If we regard an instinct as a series of acts which is made because of the innate characteristics of the nervous system, we must determine what is likely to be innate. In our analysis of any act as determined by the movements evoked by the preliminary stimulus, and as terminated by a second stimulus, we must consider both the preliminary response which starts the series of movements and the stimuli or conditions which cause them to cease, and in addition we must raise the question whether there is any innate tendency for one movement rather than another to be aroused by the stimulus. If we consider the effect of the excitation, we find good authority for the statement that a sudden strong stimulus may cause either a sudden cessation of movement, or a series of diffuse movements. When a colony of paramecia are heated on a slide, it will be noted that they either stop all movements or begin a series of excited dartings here and there which continue until the temperature returns to near normal. In the infant the excited movements are much more common. In the adult, however, one feels at a sudden startling noise or the sight of a large or strange object, an incapacity to movement, which has been suggested to be similar to the checking of movements, and which is the analogue of the 'death feigning' tendency in many lower forms.

Evidence for the existence of natively determined movements in the animal or man is relatively slight. Swallowing and eating movements in general seem to be fairly perfect

at birth in most animals, but these might well be grouped with the reflexes rather than the instincts. When one passes beyond the simplest combinations of movements, the evidence becomes uncertain. Two ways of determining what is instinctive have been suggested. (The first is to assume that any act which is present at birth falls in this class. (The other assumes that the universal distribution of the act among all members of the species would prove it to be instinctive.) The latter criterion makes instinctive acts more numerous. The second criterion needs to assume that acts may be determined by connections which are not completed at birth, but which develop later as a result of the mere ripening of the organism, and uninfluenced by experience. To decide what is instinctive we must consider the evidence obtained by each of these methods.

Instincts in Man. — To enumerate the movements which appear at birth in the animals is a task for which data are largely lacking. Few observers have kept accurate detailed records, and the many statements made in the literature seem based upon conjecture as often as upon observation. Most movements which have been carefully studied seem not to have been perfected at birth, although generally regarded as instinctive. Watson and his students have made careful studies of the first responses of the infant, and have traced the development of movements in certain individuals for as much as two hundred days. They dealt with babes in a maternity clinic where full control could be exercised over them. Sneezing was the earliest reflex. Crying was in many cases much delayed, and often came only when stimulated artificially in the attempt to start respiration. The movements of the eyes in various adaptations usually do not show themselves until sometime after

birth. Mrs. Colby in general confirmed the result. Fixation may come fairly early but convergence and accommodation may be delayed for weeks. Nursing appeared at once, but swallowing occasionally offered difficulties. Light rustling caused the infant to turn the head and the sound seemed to be localized. Loud sounds early caused evidence of fear.

Of the more complicated movements only grasping seemed to be in evidence from the beginning. A child at birth was able to support the weight of the body by clasping a rod held before him. This response earlier aroused the interest of Darwin, who regarded it as evidence that man was descended from a tree-dwelling animal, for whom survival might depend upon being able to support itself from a branch of a tree. Watson found no indication of preference for the right or left hand in the early months. Either hand was used indifferently. There was no innate capacity for swimming or even keeping afloat in the water. Crawling and all forms of locomotion were not organized at first and seemed to develop by trial and error. The separate components that were later to develop into the movements of locomotion were very early present, but there was no specific tendency to combine them in the pattern of walking or crawling. Similarly there was almost from the first a tendency to reach for and manipulate any small object that might come within arm's length. Each of these movements seemed to be entirely random. On the whole the infant has many fewer reflexes than he had previously been credited with and almost none of the complex pattern reactions that had traditionally been regarded as the instinctive equipment of man. Much more depends upon learning and much less upon inheritance than had ordinarily been assumed.

Delayed Instincts. — That an instinct is not present at birth need not necessarily mean that it should not develop later. It has been argued that just as organs may develop late, so the connections in the nervous system upon which actions depend may lie latent for a number of years and come to maturity as adult life is attained. Sex instincts might well be expected to fall in this class as might walking and the more general social functions. Of course, it is much more difficult to prove that an act which first appears in adult life or after even two years is due to an innate characteristic of the nervous system and not to learning, than it is to substantiate the claim that a movement made in the first day of life is instinctive. Appeal can be made only to the universality of the act. That is also rendered fallible if we assume that the community of experience is responsible for it rather than the community of physical structure. Children may do the same thing at approximately the same age because they have lived in a community where others acted in approximately the same way. If it exists, Allport has suggested that they might be called prepotent habits, since they are paths prepared in advance which might be developed into habits with less use than those which are unprepared.

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Evidence for Delayed Instincts. — Obviously the decision between the possibilities must be sought in facts. In man what evidence we have is that an occasional infant who has been prevented by accident or illness from walking until past the age at which children usually learn, has on recovery walked at once without going through the preliminary stage of learning by chance. Kirkpatrick and Woodworth both report instances but without a detailed account of the conditions and the number of trials before success came. Cases

are mentioned in which birds that have been prevented from flying until after full maturity have flown at once. A careful study was made by Breed and Shepard of the effects of delaying the pecking of chicks. They hatched a large brood of chicks and permitted one-half to begin pecking at once, keeping a record of the number of successful as compared with the unsuccessful pecks. The other half was kept in the dark and fed in the dark by putting pellets of meal into the beak, until they were from two to five days old. They were then given the opportunity to peck in the normal way and a record made of their successes. When the older chicks were given the first chance they were no more successful than were the newly hatched, but their accuracy improved so much more rapidly that by the end of two days they were on a par with the older ones that had been practicing from the beginning. The evidence seems to indicate that the mere growth of the animal tends to improve the capacity for performing a complicated act. If this be accepted, it could be argued for man that certain fears, the sex functions, and possibly social reactions, or the feelings which control them are instinctive, in spite of the fact that they appear along after birth.

Disappearance of Instincts If Not Exercised. — It has been asserted that instincts which are not exercised at or near the time the animal matures to the stage at which they normally present themselves may entirely disappear. An observation by Padilla, made while repeating the Shepard and Breed experiment on chicks, shows this clearly. Chicks which had been fed in the dark for fourteen days and were then brought into the light and surrounded with bits of food made no attempt to peck, and eighteen of twenty-one actually starved to death because of this failure of the nor-

mal response although surrounded by plenty of food. Even before that, the proper coördination seemed to break down gradually. The chick which at the time of hatching makes a direct thrust toward the grain, would when tested after being in the dark for eight days, make a wobbling movement first to one side then to the other of the mark. The chick's field of vision of the two eyes overlaps relatively little and he seemed to be pecking first at the grain as he saw it with one eye and then at the image presented by the other. If this same statement holds for man as for the chick, we might argue that it is well to exercise a desirable instinct soon after it is developed, if it is not to disappear.

The Nature of Selective Processes. — From what has been said above, it is clear that in learning especially and in much of what is ordinarily ascribed to instinct, a prominent part is played by the fixing of the tendency to movement through repetition. Repetition in turn is due to the results of the movement, and the degree of their appeal to the animal or individual. Thorndike and others have called this process as a whole 'satisfaction,' and have asserted that movements which satisfy are repeated, while those which produce an unpleasant effect are avoided. However it be explained, appeals which induce repetition depend upon innate characteristics of the organism and as such may be called instinctive. These processes, too, can in part be reduced to spontaneous tendencies to movement. Thus Lloyd Morgan long ago pointed out that his newly hatched moor fowl chicks would peck at any small object. When a certain caterpillar was taken into the beak, it would be at once ejected, while grains of corn or meal were at once swallowed. We would say that the chicks liked the grain and so swallowed it, while they disliked the cater-

pillars and so rejected them, but the direct observation is only that one sort of taste caused swallowing and another rejection. After a few of the particular variety of caterpillar had been taken into the mouth and ejected, others of the species were avoided, but the actual taste was required for the first rejection. The cessation of movements when a small animal comes in contact with the mother's fur and at once snuggles close and ceases all movement may also be regarded as a response of satisfaction.

The Nature of Satisfaction. — To call the occasion for the cessation of the trial and error movements satisfaction is objectionable in the first place because it leaves the process entirely unanalyzed and so rather mysterious. In the second place, the phrase frequently employed in describing the action, that the animal or child seeks satisfaction, is unfortunate since it implies that satisfaction is an end known in advance and that the seeking is definitely conscious. If we consider the second objection first, the chick or duck pecks at all objects because its nervous system compels it to respond in this way to the stimuli. We have no knowledge that any awareness of the end accompanies the act to say nothing of preceding it. It is highly improbable that it has any awareness of the sort. Satisfaction itself is as much reducible to a series of movements or forced abstention from movements as to anything else. As has been repeatedly stated, the random movements from which learning develops cease when the stimulus with which the animal comes into contact initiates a new response, or in certain cases, a cessation of response. Eating or nestling in the warm fur or feathers may be regarded as satisfaction. In this case the native tendency to make vague movements under unpleasant stimuli is replaced by the native tendency

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to make definite movements when suitable stimuli are present.

Movements, Innate and Acquired. — From the facts given above, it is clear that originally movements arise as a result of stimulating the animal in some way. The first movements are only slightly adjusted to the nature of the stimulus. No one is as perfect as it will be later in life. On the other hand none is absolutely without reference to the nature of the stimulus. Parts of the body near the stimulus move more than those more remote from it. Frequently some evidence of a pattern can be traced. How different the effect of the stimulus is from no response or from an inappropriate response is seen in the failure of chicks to eat at all, after the tendency to peck has disappeared from not being used. Evidence from chicks seems also to indicate that there may be some increase in the appropriateness of the movements to the stimulus after birth through a mere development of the nervous system, without special training. This is Allport's prepotent habit. So far as the effect of the original stimulus is concerned, all movements are alike. Those that are regarded as native are only slightly better coördinated than are the indefinite ones.

Selection Alone Is Native. — The terminal stimulus serves to select the appropriate from the inappropriate responses. If the movements be entirely random, they continue until some new stimulus presents itself which produces a definite movement. The absolutely definite responses are few in number. Swallowing belongs in this group. Food in the throat or, in the beak of the chick if of proper taste, is at once swallowed. The completion of the swallowing movement tends to induce a repetition of the

pecking movements. Much of what we call satisfaction is to be referred to a directly appropriate and univocally determined movement. This terminal response is apparently in large degree or entirely native. It is much more directly effective in determining the character of all movements, the admittedly learned as well as the so-called instinctive movements, than is the original response to the stimulation. If a case is to be made for the existence of movements due to innate connections, we must look to these terminal stimuli for them. The random responses continue until they are terminated by these more direct responses. What is called satisfaction is but the consequent of these movements. When the straight-ahead movements appear, the particular response which made them possible is repeated. The repetition establishes them and thus they are learned.

On this interpretation, learned and native movements belong in the same class. Both are finally determined by the terminal movements, which are due to native endowment. Both must finally attain a fairly closely prescribed pattern, but both attain it by an indirect method. In movements which must be learned, the random character of the first responses is marked; in the so-called instincts, the trials are not numerous and the first attempts are more nearly like the final movement, but few if any are perfect at the first attempt.

Vague Types of Satisfaction. — In certain cases the movements are not so much in evidence. Thus the fact that an animal of the carnivorous type will eat meat and refuse grass or grain points to an instinctive selection of food. This falls under our general head of one stimulus being adapted to produce a particular form of response while

another is not. Negative reactions to loud sounds may be merely withdrawing movements evoked by that particular stimulus. More general are the cases in which a stimulus serves merely to increase or diminish activities that would go on in less degree without it. The presence of other people has been shown to increase the activity of individuals in case the situation is not too unfamiliar and to decrease it if others are too near or too strange. One taps faster when with others although delicate movements may be interfered with. Here the influence is general and cannot be referred to a particular response or series of responses. These and other instances give some justification for the statement that what selects is pleasure and that pleasure is innately determined. Possibly all, or at least more than we have attempted, could be analyzed into direct response to stimulation. However it be explained, the innately determined selection of responses is largely responsible for learning of all types. Insofar much of human action is determined by the nature of the nervous system at birth. Note

Transfer of Motives. — While it must be insisted that the first act of animal or child is made as a mechanical outcome of the nature of the nervous system and of the stimulus, without awareness of the end, all later acts are influenced by the results of the first. The stimulation that originally produced restlessness soon becomes connected with the terminal stimulus which relieves the restlessness. After that connection is formed, the original stimulus initiates the same definite series of movements. In the child, at least, the memory of the satisfying end is at once aroused and this guides the movement. The experience of hunger in a known situation leads at once to the movements which earlier satisfied the hunger. What Woodworth has called Note

the 'drive' is a composite of the discomfort with the resulting restlessness plus the idea of the food that may satisfy the hunger, with a more or less definite picture of the path which leads to it. Much the same statement may be made in objective terms for the animal. The stimulus which causes restlessness has become associated with the series of movements necessary to relieve the state, and these movements come at once. Note

The Classification of Instincts. — This analysis of the instinct as a composite of the native effects of stimuli which produce chance movements and of the selection of the chance movement that will reduce the unpleasant effects of the stimulus must change the ordinary classifications that have been offered for instincts. We cannot hope to find a series of specific groups of acts which will be run through in the same way each time. We can either enumerate the different tendencies to movement that are aroused by the stimuli, or we may enumerate the different terminal stimuli, or sorts of satisfaction which will tend to make the restless movements cease. Most classifications in the past have assumed instincts to be based upon the character of the response, but in many cases they have really been divided according to the nature of the satisfaction that is given by the terminal stimuli. The acts which are guided by this ultimate satisfaction may be divided according to the major ends of life. In the use of the word 'end,' it is necessary to insist that it is a classification which is made by the observer, that the agent himself is not at all aware that the acts are subserving ends. These may be grouped according to the three biological needs: the protection of the individual, the continuance of the race, and the benefit of the social group. The first makes foods with certain

tastes satisfying, makes certain sounds agreeable, makes bodily clothing sufficient for warmth pleasant, and so on through the list of bodily needs.

Individual Instincts Simple and Complex. — One may illustrate the course of instinct by the widespread calls of birds and the acquisition of speech in man. Both the young bird and young child are incited to vague vocalization by the ordinary stimuli of a quiet moment. Both are pleased by certain characteristic notes and tend to repeat them. A child will repeat time after time with every sign of pleasure a meaningless gurgle that he has hit upon by chance. In both child or bird the sounds made by others of the species that chance to be about tend to be repeated, when by chance the individual's vocal organs hit upon them. This pleasure in the sound of others of the species seems to be the main element in learning to speak or in acquiring a song on the part of the bird. It is this that makes the child learn the language of his people and the bird the song of its species. The development of the song of various birds has been tested experimentally. If birds of one species were kept with adults of another species from the time of hatching they take over the song of the other. English sparrows thus learned the songs of canaries in place of their own. Orioles reared alone did not develop the peculiar song of the species, but an original one of their own. A child in the same way learns the language of another race if brought up altogether by members of that race rather than by its parents. The mere pleasure in repeating the sounds made by others is reinforced by the practical benefits of communication, after the language has been fully acquired.

Collecting and Workmanship. — Very similar are the incentives to what has been called the collecting instinct

or the instinct of workmanship. For collecting, an explanation is to be found in the pleasure of an accumulated reserve which seems to extend to pleasure in accumulations of any kind. Stores of food, as the reserves of a squirrel, have an obvious utility. The same justifiable pleasure may be ascribed to hoards of money or to bank accounts. Less evident is the utility but none the less the pleasure of the small boy in the miscellaneous contents of his pocket. A similar native pleasure might be assigned as the incentive to the collection of postage stamps or even of rare books. Here, however, other associated pleasures join, of which an important element is to be ascribed to rivalry, to the desire to be preëminent in some one field. Workmanship, also, finds its incentive largely in the pleasure of adequate muscular movement and in the beauty of the completed product. There is certainly no movement or group of responses connected with stimuli that could be called the instinct of workmanship. It is difficult to find any specific original restlessness that would impel to this form of response. Only chance acts could lead at first to the result. In actual practice, training in acquiring a livelihood develops the acts, and memory of pleasure in past accomplishment serves as the impelling force to the activity. As in all the responses of the adult, many other factors combine with the mere pleasure of workmanship to spur on to this type of activity. Rivalry, social approval, enjoyment of the financial rewards of good work, all combine to make the result pleasant and spur to its repetition.

Fears. — Much open to dispute is the question whether fears are instinctive. Watson, as has been said, asserts that fears, except the fear of falling and of loud sounds, are lacking in the young child and insists that all of the

1. accompanying thing.

others arise through experience that has connected the object feared with some unpleasant event. While we may grant the possibility, we must insist that it is not proven. If true it would merely transfer the instinctive element from the fear in question to the one associated with it. Certainly not all fears come from memory of actual physical pain. Whatever the cause, the child shows a constant succession of fears that appear, last for a few days or months, and then disappear, to be replaced by others. Fear of moving things, fear of living things or of soft things, fear of the dark, fear of men alone or of women alone, of children but not of adults, run their course one after another in the first few years of the life of the child. They seem to appear without reason and to vanish equally without reason. (If the fear is confirmed, it may persist for a long time; if groundless, it will ordinarily vanish as quickly and as unexpectedly as it came.) Apparently each fear is the concomitant[1] of a certain stage in the ripening of the nervous system. (When the right stage appears, the instinct shows itself; when that period of organic transition passes, the instinct goes.)

Certain fears persist into adult life. Here one has the fear of high places, the fear of reptiles and other small animals, the fear of death and of the dead, fear of the strange and unexplained, including the supernatural. These fears are probably present in some degree in all individuals whose daily life has not forced them into frequent contact with the source. (One may deny that one is afraid, one may even feel that the fear is absurd and unintelligible, but when occasion arises, the proper response makes its appearance) One may assert boldly, even haughtily, an entire disbelief in ghosts and the supernatural, but not be able to pass through a cemetery alone at midnight

without feeling in some slight degree uncomfortable, unless, of course, such promenades have been frequent. Again one cannot hold the finger relaxed against the glass of a cage while a rattlesnake strikes at it, and that in spite of positive assurance that no harm can come from the act. I have even heard a rustling in the brush in a region where there were no dangerous animals, have decided that it was probably made by a small lizard and been curious to see it and then suddenly find myself starting with the emotional accompaniments of fear. Here the instinct asserts itself after a rational interpretation of the incident has been made that is opposed to the instinct.

Laughter. — Of instinctive responses made indiscriminately to a number of stimuli or situations, one of the most frequent is laughter. The response needs no description. The occasions for it are almost as numerous as for fear. In general the situations that arouse it are favourable to the survival of the individual, in opposition to the danger connected with the situations that arouse fear. It has been suggested that one laughs when pleased, or when there is a release from fear or other tension. Others assert that laughter comes only when the self is triumphant, usually at the expense of another person. Certain it is from records of childrens' laughter that it is more frequent in the group than when alone. On the whole we can only say that no single type of situation can be assigned as the sole occasion for laughter, nor is it easy to see what the value, for survival, of the response may be.

Other instincts that have been asserted to be present in the human child and adult are fighting, self-assertion, cleanliness, and disgust. Each of these may be primarily referred to the initial restlessness or to vague satisfaction

or dissatisfaction with a situation. Some may involve both. Cleanliness has been denied by Watson to be instinctive in the infant. The infant showed no objection to paste on his fingers or to any of the other forms of uncleanliness to which he was subjected. Much of the dislike of filth in the adult is probably due to transfer from other associated disagreeable objects or results. Fighting is the development from the anger responses of the infant and to opposition of all types, physical, mental, and moral. The original diffuse responses are coördinated and adapted to different situations through learning and transfer. There is no distinctive pattern in the responses, and no common end or form of satisfaction that is ultimately attained. Self-assertion again is more a pleasure in seeing one's self in a prominent place or resistance to being neglected or subordinated than a specific response. The latter is a frequent stimulus to beginning a fight. In many of their occasions and in many of the responses aroused, the two instincts have much in common. All four serve better as illustrations of how many factors combine to produce what we call instinct in man than as illustrations of distinct instincts.

The Racial Instincts. — The racial instincts are also very numerous and are highly coloured by emotion. In the lower animals they are very widespread and very striking for their definiteness and adequateness, in spite of the slight knowledge of their purpose that can attach to them. The egg-laying instincts have already been illustrated. The nest-building instincts are almost as numerous and require greater complexity of response. Race instincts in man are equally important and have as little of their real purpose revealed in the consciousness of the individual as have the corresponding instincts of the lower animals. The innocent

adolescent youth is as surprised at his thrills as he gazes upon the beautiful object of his first love and may be as ignorant of their cause and purpose as is the beetle that is laying its eggs, or the robin that is building its first nest. Even when the instinct is understood, there is little reference to that knowledge at the moment. The emotion is not controlled by it and not altogether appreciated in its full bearing. Similar instincts without consciousness of purpose and in advance of practice may be seen in the coquetry of the young girl. It apparently makes its appearance as naturally as the unfolding of a leaf, although the art may be perfect when measured by the most mature standards. The responses are not always definite and what characterizes the instinct is essentially the pleasure in the presence of the beloved object. Equally striking is the emotion of jealousy and the acts connected with it, which crop out as spontaneously and irrationally as the love emotions themselves.

The Parental Instinct. — Care of the young after birth furnishes an excellent example of the fact that what is instinctive is the pleasure at the presence of certain stimuli rather than a pattern reaction. At least aside from nursing, the care of the child is almost entirely a learned response. Almost any adult, especially a woman, is pleased at the sight of a child that is healthy and happy and is much disturbed by signs of discomfort. The mother is stirred to her care of the child by these two fundamental emotions. Tradition, and books on the care of the child, physicians' advice and earlier disturbing results teach her to anticipate the discomforts and indispositions and to avoid them. There is certainly nothing of the pattern type of reaction. The drive is to be found in the pleasure at sight or thought

of the healthy child and distress at ill health. The responses themselves are determined by knowledge with a little learning through trial and error.

Social Instincts. — The social instincts also express themselves partly in evoking indefinite or explicit responses and partly in furnishing stimuli that will terminate these responses, either by a pleasant quiescence or the substitution of other definite activities. There are few if any immediate pattern reactions induced by the stimulus of other people. The immediate responses are the fear reactions of flight, and the vague responses or paralysis that may be seen in the youth when thrown with strangers. These persist in some degree to adult life and may be suffered by any one before a strange audience, the well-known stage fright. Among the responses that favor social life is the vague restlessness of lonesomeness that makes the man in a strange place wander at random until he finds companionship. When long deprived of the society of his kind a man develops an actual hunger for social contact and conversation that expresses itself in vague bodily responses of homesickness.

Sociability. — The stimuli from the group that put an end to the indefinite movements are the pleasure in the presence of other members of the species that we know as sociability. The lonesomeness disappears when in a congenial group. This resembles the way paramecia are held in groups. Wherever they come together, the breathing impregnates the water with CO_2. Then the water outside, free from CO_2, induces a negative reaction which drives all who start away back into the mass. Whenever a wanderer comes within the group, he must stay, held by dislike of the pure water outside. In man it is a cessation of restlessness when with others. In man, too, of course the thought

of the place where men are to be found drives the individual to them.

Sympathy. — A more specific instinctive response towards others is the feeling of displeasure at the sight or thought of the suffering of others. This we know as sympathy, — suffering with others. It is the incentive to most of charity. The end alone is determined by this instinct also, — the acts that shall relieve it are altogether a matter of choice or trial. When one gives a coin to the beggar on the street corner, one does it not so much to relieve the beggar's suffering as one's own. If under the influence of the teachings of sociology one refuses to give, the thought of the refusal will produce for some time an unpleasant emotion. The instinct asserts itself in spite of the belief that the man is an imposter and may be better off than one's self. Much has been made of this instinct by certain of the modern schools of ethics as the source of all altruistic action, and no doubt it deserves a very high place among the forces that make community life possible.

Self-Sacrifice Instinctive. — Related to sympathy is the so-called instinct of self-sacrifice. In the animals this may be a pattern reaction. In man the thought of giving one's self for the sake of the group is sufficiently attractive at times, in war or emergency, to make him undergo great danger to save another or the state. It is this satisfaction in the thought of doing something for another that is innate rather than the tendency to any act. Every instance of self-sacrifice is the expression of one or the other of the social or racial instincts. If one asks how an instinct that leads to the possible destruction of the individual could have survived in the struggle for existence, one must find the answer in the survival of the group rather than of the indi-

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vidual. Gregarious animals are on the whole more likely to live if the stronger are ready to fight for the preservation of the weaker. The male deer, that are said to form a circle about the females and the young when attacked by wolves, make possible the continuance of the species even if a large proportion of them succumb to the attack. And in the early stages of human development those tribes would survive in which each member would be willing to lay down his life for the welfare of the whole. Gregarious animals survive in the group, not individually.

Social Pressure. — More general as a social instinct is the effect of the opinion of the group in determining all action. In its most fundamental aspect this goes back to the fear of the mass, mentioned above, and enjoyment of the approval of the group. The fear of the mass is at first vague. One attempts no activity before a group or is awkward in what one does attempt. This is restricted to finding any act that is disapproved by the group unpleasant, and then to avoiding any act that one believes will be disapproved. The taboos of primitive society are enforced by this disapproval. On the other hand, one is pleased and will continue the acts that are approved, that are cheered by the crowd or merely bring smiles of acceptance. This instinctive pleasure at social approval and discomfort from social disapproval constitute furthering influences for one type of activity and check the opposing group. In this way they determine what acts shall be learned and what inhibited, what habits shall be acquired and what knowledge established. The effects of all other instinctive activities are subordinated to and controlled by social pressure. It expresses itself as convention or as good form. It is bad form to show greed, it is not polite to exalt one's self. The

man of good breeding restricts these impulses to the limits set by his fellows. The racial instincts are controlled by the customs embodied in the laws of marriage and divorce. Social pressure is the great controlling force of civilization. It again is not enforced by physical pain. Social disapprobation is a greater punishment than any bodily suffering.

Complexes of Instincts. — Play. — Many activities may be grouped as showing not one instinct or even instincts from one of our groups, but as falling under several different tendencies, even into two or all of our larger classes. The most prominent of these is play. So large a part does play have in our life that Woodworth, classifying from a standpoint different from ours, makes it one of his three great groups. It is probable, however, that it is not a true instinct or at least not a single instinct. If one will watch the games of the boys or girls upon the school playground, one will observe that each game is the expression of an instinct or of many instincts. Emulation or rivalry enters as a factor in almost every contest. Sociability and the advancement of the welfare of the band arbitrarily formed can be traced in many of the sports. One may even see evidence of instinct in the content of some of the games. Playing with dolls is undoubtedly an early development of the parental instinct. In general the favourite games of each sex show evidence of instinct. But the games in their specific forms are also influenced even more by the environment and by the activities of parents and friends. The only thing that can be said to be common to all forms of play is the tendency to some sort of purposive activity, the inclination of the child to be always in action. This is not so much an instinct in the ordinary sense as a physiological law, that surplus energy will find expression

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in action. Various instincts and habits guide this expression. Play is the expression of a law of the physical organism, and so far as it is instinctive, it is the expression of a number of instincts, not of a single one. Note

Instinct Limited to Drive and to Selection. — We may accept instinct as furnishing the ultimate incentives for practically all of human conduct. What is instinctive is in very slight degree the specific response. All acts start from some stimulus internal or external that drives to action. The movements initiated are indefinite in character and generally diffuse. The primary force in the development of the instinct, as of habit, is a selection of the results of these movements. This selection itself may be regarded as generally due to some new stimulus with which the diffuse movements bring the organism into contact. This removes the occasion for the undirected movements or starts new more specific responses that ultimately remove them. We ordinarily speak of the first condition as discomfort and of the latter as satisfaction, but the responses are primary for explanation, and the discomfort and dissatisfaction are incidental or derived from them. In actual observation, it is seen that when the stimulus presents itself that terminates the period of restlessness, the animal either merely quiets down or turns to regularly coördinated acts. These tendencies to become quiet are themselves inherited or dependent upon inherited connections. Satisfaction and its opposite are related to these responses, but the satisfaction is dependent upon the responses rather than the responses upon the mental state. Pictorially, we may look upon these selecting activities or satisfactions as the bait which attaches to the acts essential for survival. Only so much as is essential to start the act is pleasant. Once

N. B.

1. sensory extends inward from a sense-organ

2. motor extends outwards toward a muscle.

started, they take care of themselves. These pleasant characteristics indicate no more than the rough outlines of the acts. The rest must be learned from experience. While beneficial foods are in general pleasant, there is no cessation of pleasure in food when one has eaten enough. Were that the case the physician would have little to do.

The Physiology of Instinct. — The nervous basis of these instinctive tendencies can all be found in the inheritance of connections between sensory and motor neurones. For the few immediate responses the connection between the specific stimulus and the corresponding response would be innate as in the reflexes. Where we deal with the more general phenomenon in which the response is built up as a process of connecting a stimulus that produces a vague initial restlessness with a specific response that gives a general satisfaction, we must analyze into several parts. The initial restlessness is to be ascribed to the opening at the same time or successively of a number of different paths. That is characteristic of responses to new situations. The selection comes by a new stimulus arousing new responses. This would also be due to open synapses or to paths preformed at birth. The quiet nestling of a young chick under the mother's body is a specific response that ensues upon restless rushing about, evoked by the initial stimulus. The satisfaction of the mother at the presence of a happy child is more negative. It is to be given a positive character only when opposed to the restlessness of listening to a crying babe and the indefinite responses that result. While complete analysis of what constitutes the nervous responses in satisfaction or its opposite is not yet made, we can refer the processes in general to lack of stimuli to the diffuse responses, or to the presence of stimuli which produce

specific coördinated movements. Further analysis must be left to the theories of pleasure.

The Origin of Instincts. — Even if all that is inherited is a tendency to repeat movements that cause satisfaction or definite movements, it is a proper question to ask how these tendencies are acquired in the race. This problem is entirely a biological one. Two explanations have been given of the origin of instincts. The simpler is that instincts are merely inherited habits. On this theory some ancestor learned a movement, and the habit was transmitted to his descendants and became a racial possession. Were the biologist willing to accept this theory, the explanation of the origin of instincts would be very simple. Unfortunately for the theory the evidence that a change wrought in one individual is transmitted to his offspring is not accepted by the great majority of biologists. Weismann has demonstrated to the satisfaction of many of his colleagues that the structures of the body are so completely set off from the tissues which are to continue the race, that the changes in the body have no influence upon the inheritance of the offspring. The cells from which the progeny are to develop have in potentiality at the birth of the individual all the characteristics that they later reveal, — they are influenced only by the factors that weaken or destroy the body as a whole. Whatever be the outcome of the biological controversy, it is necessary for the psychologist to construct a theory of instinct on the assumption of the accepted biological theory.

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Instinct a Product of Natural Selection. — On this theory of Weismann, instincts come not through a change in the habits of the individual, but through some chance change in the characteristics of the germ plasm. It is a fact that,

while the characteristics of the parent are transmitted, they are not transmitted accurately, there is always variation in the characters. If one sows a thousand seeds from the same plant, the young plants will show a wide range of variation from the parent plant and from each other. The theory of the development of instincts assumes this same tendency to variation in the nervous system and in the instincts that correspond to the nervous connections. If this known fact of variation be accepted, all that is necessary for the development of an instinct is that some selection be made from the variations. This selecting agent has been found by all the evolutionary theories in the environment. When a variation in response better suited to the environment than the older responses makes its appearance, the animal that shows the variation will be more likely to survive. If this variation is inherited, as it tends to be, the offspring of this animal will survive in greater numbers and in time will outnumber those with less adequate responses. In brief, variations in responses are constantly appearing as the result of changes in the structure of the germ plasm. The animal that has the more beneficial responses will live and its offspring will increase, while any animal that develops variations unsuited to the environment will be destroyed, or the offspring will be fewer. As a result of this variation in structure and response, and consequent selection of the animals that show suitable variations, instincts become constantly more suited to the conditions of life, and also become more and more complicated. Variation and selection can account for any instinct, granted only a sufficiently long time for the variation to develop.

Suppose, for example, that we have a large number of

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rudimentary organisms with all possible combinations of two responses. Assume, *e.g.* that certain organisms in the mass seek food and flee dangers, that others flee from food and seek the dangerous stimulus, that a third class flee from both food and the dangerous stimulus, while the fourth seek both. (Of the entire group, only the first class will long survive,) the others will either starve to death or be eliminated by approach to dangerous stimuli or organisms. Each variation of the primary responses in the progeny will lead to similar elimination, or, as the responses become more numerous and more adequate, a greater proportion of the generation will survive. In time, we would have a set of instincts that would serve to protect the organisms from the more evident and usual dangers. The whole process of development of instincts is thus due to the development of the physical structures upon which these responses depend. But it does not follow that instincts are necessarily simple. Many instincts even of comparatively low animals are extremely complex. The egg-laying instinct of the Yucca moth, cited by Lloyd Morgan, is a case in point. The eggs of the moth are always laid in the seed pod of the Yucca plant, and after they are deposited, pollen is gathered and placed in the hollow pistil and fertilizes the seeds. It is a movement that could never have been learned and the moth can have no idea of its purpose, for the moth dies at once after the process is completed. The continuance of the species of both the moth and the plant depends altogether upon the accurate performance of the act. The larvæ when they hatch need the developing seeds for food; the seeds of the plant would not be fertilized and consequently would not develop without the aid of the insect. In such a case the instinct has all the outward signs of intelligence, but

must have developed without the aid of intelligence. It should be added that instinctive responses that were indifferent to survival would tend to persist. The animals that chanced to develop them would live. This accounts for the fact that not all instincts are useful.

Summary. — Human and animal conduct is determined in part by innate tendencies. In function, on the one hand, they serve to keep the infant alive until he may be able to learn for himself; on the other, they enforce general lines of conduct essential to the preservation of the individual, the race, and the social group. As opposed to habits and rational activities, what we call instincts are vague and prescribe only the end to be attained, not the precise means. Even the specific responses are soon modified by habit. Instincts cannot be set apart from habits and other intelligent movements in the adult; all that can be said is that certain acts are more largely native, others more largely acquired on an instinctive basis. The advantages of an inheritance of the vague outlines of action only with much left to individual learning are evident, if one will but consider the relatively small number of movements that may be inherited and the great number of situations to be met, not to mention the great possibility of change in the environment. Were an organism to be rigidly limited to a few forms of response to predetermined conditions, it would soon find a situation for which it was not prepared and be eliminated. Or if the environment should change in some way, the organism could not long survive. An endowment of few and relatively indefinite innate responses with much capacity for learning at once relieves the necessity for multitudinous predetermined responses and assures the preservation of the organism until it has time to learn.

Notes

QUESTIONS

1. How do impulses spread from sensory to motor neurones?

2. Give illustrations of acts in a babe which are due to native paths and to those which have developed in the life of the individual.

3. What crosses a synapse according to Sherrington? What else might cross?

4. How may synapses be changed through use? Give three theories.

5. How many of the first movements are diffuse and vague as compared with those that are definite and simple?

6. Give an instance of a tropism, a reflex.

7. What are the modern objections to the older definition of instinct?

8. How many innately determined responses does Watson ascribe to the human infant?

9. Give the evidence for a delayed instinct. How different from a prepotent habit?

10. Define satisfaction. Can it be analyzed into specific tendencies to response?

11. Which is the more likely to be inherited, the tendency to make a specific response or satisfaction?

12. A dog has been taught to beg for food. One of her pups goes through the begging movement without having seen the mother perform it? Is this an instinct? Could it be an inherited tendency from the mother?

13. What is the modern biological theory of the development of instincts?

14. Do we classify instincts traditionally by the movements or the end subserved?

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CHAPTER V

MOTOR LEARNING

Learning is a process of forming new connections between a sensation or stimulus and the motor mechanism, or between two sensory areas in the cortex. In most cases learning is merely an intensifying or increasing of a connection that was originally slight, for probably, wherever learning occurs, there must at birth have been a tendency for the formation of a connection. We may distinguish three types of learning. First is the acquisition of ability to solve a puzzle, which has been mainly investigated on animals. Second is the formation of a simple connection between a stimulus and some reflex movement which is not naturally associated with that stimulus, what is known as conditioning of the reflex. Third is the formation of associations between sensations or between sensations and memories which we see in man in the ordinary learning. As nervous processes these three types of learning are very much alike. They are probably merely different applications of the same general principle. They differ in the method of measurement, and in the varying degrees in which motor and sensory elements intermingle with each other.

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The Learning Experiment in Animals. — The first experiments on animal learning were conducted by the method of putting cats and dogs in cages provided with doors which opened by simple catches, and keeping a record of the way in which they learned to get out. Later, studying the ways

in which they learn to run a maze has been a favorite means of investigating the laws of animal learning. Both illustrate very clearly the close connection between the instinctive responses and learning. Thorndike, who first studied cats by this method, asserted that their learning was altogether by a process of trial and error, with a selection of the suitable response by a stamping in of the movement through the satisfaction due to obtaining food. The cat would be stimulated by the discomfort of the confinement and by hunger to make all possible movements and some one of them would, purely by chance, lead to opening the door. note After eating, the right movement would be emphasized or 'stamped in' by the resulting satisfaction and would tend to be repeated. Successive repetitions connect it with the stimulus of the box until, gradually, confinement in the cage leads at once to making the correct movement for opening the door. Learning is gradual. If the time required for escape is plotted, it is found that there is a relatively rapid descent in the curve at first and then a slower and slower decline, until the straight line is reached.

Learning and Instinct. — This fits very neatly into our analysis of the instinctive process. Hunger plus confinement at once forces the animal to make a series of indefinite movements, which are determined by the paths that happen to be open natively or through earlier learning. By chance these open the door, and the cat follows the habitual tendency to go out and eat the food that is kept in sight as an incentive to struggle. The eating may be regarded as instinctive and the innately determined pleasure from the eating aids in impressing the one chance act that succeeds in opening the door rather than any one of the others which fails. Experiments have shown a few cases in which the

animal will open a door by accident and not recognize it. This was especially the case in some experiments by Watson in which white rats learned to open a door by running out on a lever connected with the door. On several occasions the rat would come down the lever and go directly past the door which led to food without entering the open door. Here learning was incomplete because the terminal stimulus did not evoke the response that would have stamped in the successful movement. Instinct, regarded as the expression of innately present connections, determines the preliminary movements, and, as satisfaction in eating, aids in fixing the connection between the movement which made possible obtaining the food and the stimulus.

Learning a Maze. — Other studies of animal learning have used the maze. The early mazes followed the Hampton Court maze in pattern. The cut shows the outline (Fig. 25). The rat is placed at the opening and must find his way through all the turns until he reaches the food box. He is assumed to have learned it when he can make two perfect runs in succession. The problem differs from the problem box since a number of movements must be tied together in a series before the goal is reached. (The original position and the terminal food stimulus which gives note satisfaction are separated by a number of movements instead of by one.) Here the original stimulus and the final one which gives satisfaction are separated in space by a long distance and in experience by a number of different acts which must be worked together into a series before learning is complete. A number of stimuli must also work together to guide the animal, usually in these experiments a rat, as he makes the different turns. It has been shown that the rat is aided by light when it is present, but a maze

will be run successfully by blinded rats. Contact may be used, but need not be as animals learn when deprived of their vibrissæ. Watson and Carr long ago decided that rats were guided mainly by the kinæsthetic sensations from their muscles, that they learned that they should turn after a certain distance in one path. This conclusion was seemingly necessary when it was found that rats deprived of the sense-organs of sight, of smell, and of contact could still succeed in learning a maze. Recently Shepard has found evidence that the normal rat finds his way through the maze guided by the sound of his footsteps.

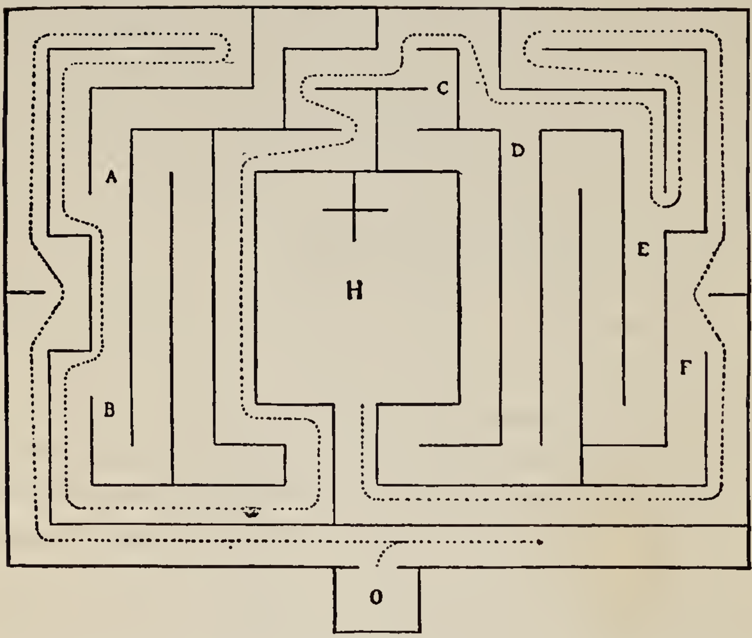

FIG. 25.—Maze copied from the Hampton Court maze, adapted to animal learning. The animals are put in at O and must find their way to H, where they are fed.

Maze learning differs from the ordinary problem solving in that a large number of different turns must be associated

in a series before learning is complete. (The difficulty in explanation is that it is not the turns which have been made most frequently, but those which lead directly to the food box which finally become established.) The assumption usually made is that two movements which most frequently succeed each other become connected so that they will always succeed each other. In the maze the rat will run into each blind alley at first, but after entering one several times he will begin to go a shorter and shorter distance into it and then will pass without entering at all or with only a momentary hesitation. If the maze be so constructed that all paths lead to the food box, but one is direct and all the others are round about, the rat will in time learn to go by the shorter way in spite of the fact that he has reached the goal more frequently by the longer ways. Learning is not a mere connecting of one turn with the next one before and after it, but is the formation of a system or pattern of responses, in which the pattern which attains the goal most quickly and easily is retained and the others are discarded. In the patterns apparently each part influences all other parts whether it is near or remote from that other. In this learning, (the rat masters the portion of the path nearest the food box first and the more remote parts are mastered later) Learning the maze is like learning to escape from a cage. It differs from it mainly in the necessity for combining a long series of movements one after the other before the end is attained. (It seems that there is a conflict between rival patterns in
Note which the most adequate finally wins in the struggle)

Humans in a Maze. — Adults and children show much the same type of learning in the maze as do animals. When an adult is placed in a maze large enough to permit him to

walk through it, he spends rather more time in observation and less in random running about than does the rat, but his thinking is nevertheless quite frequently wrong when he has given full thought to his action. The child is more active and depends less upon thought, and so makes more errors early than the adult. The animals depend much more upon undirected trial, run much more rapidly, make more errors at the beginning, but attain final complete learning about as quickly as do the humans. In learning to discover the way through a maze printed on paper, in which the observer looks through a tube so adjusted as to conceal all but the one square he is presumed to follow, the adult human is on very much the same level as the animal. Here learning comes gradually, but foresight and memory of the conscious type are relatively little in evidence. Individuals may be given the same pattern repeatedly and they will learn it in different connections, each time without recognizing that it is always the same. This is of value in indicating that the peculiarly mental processes are not obviously important in learning of the maze type even in man.

Insight in Learning. — As opposed to the interpretation of learning in terms of the more simple association and satisfaction processes, the stamping in of the movements induced by trial and error through success, Köhler and others have insisted that animals show what they call insight in learning. It is assumed that the problems are solved mentally and the solution is then applied to complete the action at once. see example in notes
The evidence for this view is largely that on occasion an animal will observe for some time without movement and will then solve the problem at the first attempt. Köhler first noted this type of behaviour in apes. One was shown

a banana in front of the cage, and then given two pieces of bamboo, one small enough to fit into the other, and each too short to reach the banana. After some time spent in contemplation, the ape suddenly put the smaller stick into the larger and reached with the lengthened instrument through the bars of the cage to fish in the banana. After the first success, he was apparently so pleased with the tool that before eating the banana, he reached every loose object near enough and brought it up to the cage.

Learning in Ideas. — Yerkes and his students, especially Adams, who repeated Thorndike's experiments with cats, have argued that animals may put together the various parts of the process in ideas before they make the actual trial. Adams interpreted the period of delay before the cat attempted to undo the fastening as thinking out the solution. He is impressed by the cases in which the cat seemed to attain the end suddenly after long delay, as Thorndike was by the general slow progress of the learning, and the slight influence exerted by seeing other animals solve the problems. It is to be objected to both theories that they contain more of the negative than of the positive explanations. Insight in man is not a well recognized process. To apply the term to animals means merely that learning comes in some unknown way rather than by trial and error or other definitely analyzable method. To say that ideas are used is somewhat more specific, although the evidence that they are really effective in the cat's work is very slight. As was said of learning the maze by men, ideas seem to be of relatively little aid, and the same may be asserted of the way men learn mechanical puzzles. Frequently a man learns to take a wire puzzle apart before he sees the principle. The ideas are apparently of little value.

The Conditioned Reflex. — A much simpler case of learning is offered by the study of the way one reflex may be transferred from its normal stimulus to some other. Pavlov, the great Russian physiologist, became interested in the phenomenon while studying digestion and has devoted years to its study. He found that if he applied powdered meat to the tongue of a dog, he would at once start a flow of saliva. Then he found that if for a few times he sounded a bell just before he applied the meat, the sound of the bell would then stimulate the salivary secretion when given without the meat. The method of forming a connection between the sound of the bell and the reflex secretion he regarded as typical of all learning processes. Its use permits the study of the laws of forming fundamental connections without any of the disturbances which might be introduced by the mental processes of a man. The results of Pavlov show that the stimulus that is to be made to excite the flow of saliva must come either shortly before or simultaneously with the stimulus which excites that flow naturally. If it comes after the natural stimulus, no effect is produced. It may come as much as half an hour before. The more frequently the two are presented together, the stronger is the tendency for the indifferent stimulus to arouse the salivary reflex. The effect will last for a considerable period but becomes weaker and weaker with the passage of time. The effect may be destroyed by repeating the sound of the bell a number of times without supplying the meat. After the bell stroke has been repeated a number of times at the same sitting, the saliva will fail to flow, but the bell will be effective again on another day. If the repetition is given on numerous occasions without presenting the meat, it will lose its effect entirely. The original

connection of bell with meat is known as conditioning and the breaking of that bond is known as de-conditioning.

Several minor factors in the determination of the conditioning are interesting as showing the similarity between this primitive animal process and human learning. (Thus the ringing of the bell will cause a secretion of saliva only when all of the conditions are the same as in the original experiment.) The animal is always put into a harness which holds his head in place. He has previously had the duct of the salivary gland dissected out and brought through the cheek so that it will drip into the scale pan of a balance or a funnel instead of into the mouth. This procedure makes it possible to measure or weigh accurately the saliva secreted. If now any of these parts of the experiments are omitted, the secretion will not be induced. Similarly, if there is any indefinite noise about, the flow will be inhibited. On one occasion the experiment was not successful, and it was shown that the buzzing of a fly was responsible for the failure.

The Explanation of Conditioning. — Why the two stimuli given in succession should become connected has been much discussed. Various hypotheses differ in particulars but all agree on the general fact that in some way when two parts of the nervous system are active at the same time, they tend to become connected in such a way that forever after, when one is excited directly it tends to arouse the other to activity. Thus the taste of the meat stimulates the secretion of saliva. When the bell is heard at the same time or just before, a path tends to become established between the sound and the motor path of discharge to the gland which was open just after it. Whether the connection goes to the neurones active during the tasting and thence to the

motor path is not clear. We have evidence in the ordinary formation of associations that such connections are formed without appreciable motor discharge. Pavlov insists that the connections between the sound and the salivary discharge are formed in the cortex, for unless the cortex is active no such connection develops. This, however, would not be essential to the theory. The path would be explained in the same way were the thalamus alone involved. All that we need to insist upon is that simultaneous or immediately successive action of two parts of the nervous system, especially of two parts of the cortex, will develop a path of connection between them of such a character that one, when active, will excite the other to action.

Conditioning in Daily Life. — Since the introduction of the term conditioning, many have treated all action from that point of view. It has been shown that children show the salivary conditioned reflex in the same way as does a dog. More directly important are the tests which show that the fear responses can become attached to any harmless object and when attached, they can be removed by a slower process. Watson and a student succeeded in connecting a fear response with a rabbit by making a disagreeable sound by striking a steel bar on several occasions when a pet rabbit was near. Later whenever the rabbit was brought near, the signs of fear were shown. Removing these fear processes can also be accomplished by presenting the rabbit a number of times without the sound, but under pleasant circumstances. Watson introduced the rabbit into the room when the child was eating and kept it in a cage at a distance so great that no fear was produced. It was gradually brought nearer on successive days, until it was put upon the table. Finally it could be put into the child's lap without causing

any signs of fear. It is asserted, with probability, that many transfers of responses and emotions from one situation to another in everyday life can be explained on the analogy of conditioning. When a dog is broken of chasing chickens by a few sound whippings, one may speak of negative conditioning. Many other instances will suggest themselves to the reader of both positive and negative conditioning.

All of these types of learning are but different phases of the same general principle that movements made in response to stimulus tend to become connected with that stimulus in such a way that the stimulus will evoke them in greater strength, or will be more likely to evoke them the more frequently they have been connected. The first response may have been made because that was one of many paths into which a nerve impulse excited by that stimulus might have spread. The results of the particular movement cause it to be repeated and that repetition makes it more likely to be aroused again when the stimulus is the same. The conditioned reflex is different from this only in that the movement or secretion which is natively aroused by one stimulus can be attached to another stimulus given repeatedly with the first. On the side of the nervous system, this probably means that two parts of the nervous system which are at any time active together tend to have impulses drain from one into the other so that the one not at first capable of arousing a reflex may later acquire that tendency. This is the same principle which we shall use in the next chapter to explain much of the more mental forms of recall.

In man and the higher animals the final effects of all types of learning are seen in habit. Most of the acts of the adult

are determined by habit. They are performed quite as immediately and with almost as little consciousness as are the reflexes. Most of eating, walking, talking, and all of the ordinary actions of everyday life are habits in whole or in part. Dressing is a habit. You do not think as you put on your garments. Your hands find their way to the buttons without thought and thought may even interfere with the performance of a thoroughly habitual act. The tie is adjusted with no awareness of the separate movements. Were you asked to describe the movements made in tying a cravat, you could not, although the operation is run through daily without mistake. Here as in the conditioned reflex, you may interfere with a habit if an unessential element is changed. One who had suddenly become totally blind insisted on standing before a mirror as he shaved. It was the usual place and it aided confidence although it could have had no influence upon the actual movements.

Habit and the Synapse. — Habit is simply the result of the changes in the synapse, wrought by frequent passage of a nerve impulse. When a nerve impulse passes by chance across a synapse, it leaves some effect which persists. It matters not whether the passage comes by undirected accident as in trial and error learning, whether it be due to conditioning, or by a spill over from a reflex; provided the impulse passes, and the passage is repeated frequently, a habit will be formed. The more frequently the movement is repeated, the more likely is it that the stimulus which produced it will arouse that movement and no other. These changes in the synapse persist for a longer time, the more frequent the repetition. Some when thoroughly established last without renewed exercise for years. Skating and dancing are accomplishments which, once thoroughly learned,

are little disturbed by the passage of time even when they are not practiced in the interval.

The Omnipresence of Habit. — The process of forming a habit is relatively simple, but the effect of habit formation has the most far-reaching importance. Every act of any kind is the forerunner of other acts of the same kind. At first the habit is easily changed; but if frequently persisted in, the time comes when that movement must be made whenever the particular occasion presents itself, without reference to the other circumstances of the moment. Obviously when the movements are repeated until they are so completely fixed, it is essential that the movements chosen for fixation shall be helpful or at least harmless. The useful man is for the greater part marked off from the useless and the vicious by the nature of his habits. Industry or indolence, good temper or bad temper, even virtue or vice, are in the last analysis largely matters of habit. One forms the habit of working at certain times of the day, and soon if one is not busy at that time, one experiences a lively sense of discomfort. Or, on the contrary, one forms the habit of loafing all day. Work then becomes distasteful, and indolent irresponsibility is established. Losing one's temper is largely a habit, as is self-control. Each time one is provoked by a trifle, it becomes the more difficult to look calmly at an unpleasant episode; while each time one remains calm under difficult circumstances, strength is gained for later difficulties. Similarly, whenever temptation is resisted, virtue gains a victory; when temptation is yielded to, new weaknesses develop. Frequent yielding makes resistance practically impossible. A bank president of established morals could no more step out and pick a pocket that was temptingly unprotected than he could fly. The habitual

drunkard can no more resist the invitation to have a glass than he can resist the action of gravitation while falling freely through space. (Frequent giving in has entirely destroyed his original freedom of choice.)

We are all constantly forging chains of action in our nervous system that we shall never be able to break. Fortunate is the man whose chains are all suited to the life he is compelled to live. He was once free in the sense of our present problem, but after a few experiences he becomes bound to his past by chains that only the strongest impulses can break. Habits are not restricted to action, but show themselves even in the features. Much has been said, particularly in semi-popular writing, of the ability to determine character from the face. Each movement of the muscles of the face has left its impress upon the muscles and the skin, just as each action has left its impress upon the nerve-cells. One can tell by a glance at the face, even in repose, what its most characteristic responses have been and can form some idea of the character of the man, of the effects that have been left by the same actions upon the nerve-cells which show themselves when the man is called upon to act. A weak man, a strong man, even more truly a jovial man or a crabbed man, carries the marks upon his face. These marks are but evidence of the changes that the same set of acts has left upon the synapses of the nervous system everywhere along the paths of action.

Habits Essential to Action. — Habit not only limits choice but through early training makes choice possible. The adult ordinarily chooses one habit rather than another; he does not choose between some habitual action and something never done before. What has never been done is ordinarily not within the power of the individual. For

example, you cannot speak the Russian word for prince and could not if some one should first pronounce the word for you. You cannot because you have never developed the habit. When you do choose to speak an English word, you do it because you have that habit fully developed. Had you never formed habits of speaking you would be as powerless in English as in Russian. As all of our intellectual operations are expressed in language, habit is in the highest sense a powerful, an indispensable tool of thinking. But that is not all. If you eliminate from the various intellectual activities all that belongs to habit, most of the higher mental operations become impossible. Habit, like fire, is a cruel master but an invaluable servant. Without it all action would cease or at the best become but a painful process of feeling one's way through even the simplest act.

Association of Ideas a Form of Habit. — The association of ideas, fundamental for thinking, is similar to habit. The recall of any memory necessitates the stimulus of some earlier connected event. An old experience returns only in connection with some other event now revived in consciousness. On the nervous side this means that the cells in the cortex corresponding to the two ideas have been active together and that the resistance of the common synapse has been reduced by the simultaneous action of the two neurones. When one presents itself, the impulse spreads through the synapse of least resistance to the related cell and the old idea is recalled. All recall is dependent upon the connection of ideas, and ideas are connected only as the neurones are united through the reduced resistance of the synapses. The association processes are thus in every particular similar to habits. They might be called habits of neurones in the cortex. The only difference

worth emphasizing is that in this case there is no movement of muscles accompanying the activity of the cortical cells. Even this difference is not always present; for the cortical cells, whenever active, tend to call out movements, often very slight, sometimes nothing more than the tendency to movement. If we include association among the habits, we may say with complete assurance that no intellectual activity of any kind goes on except on the basis of habit. Habit and association are the two fundamental facts upon which all of our activity, mental or physical, depends. That either should be lacking is inconceivable. Were they lacking, man, either as a mental or as a physical being, would not be what he is.

QUESTIONS

1. What native factors are involved in learning? How is the mechanism of learning different from improvement of an instinct?

2. How do cats learn to get out of a box, according to Thorndike? According to Adams?

3. How and why are the false turns dropped in learning a maze? Is it a connection of next to next or a choice of patterns?

4. How was the original 'conditioned reflex' experiment performed? Why will a later stimulus not excite the reflex?

5. How does the nervous process in conditioned reflex differ from that in habit formation?

6. What is meant by 'insight,' and how is it supposed to apply to animal learning? Give the evidence that learning may be by insight rather than by trial and error.

7. Name three important activities at different levels which may be called habits.

EXERCISES

1. Try to take apart any simple wire puzzle and list the separate movements you make. Is the successful movement a result of insight, *i.e.* thought, or chance?

2. Try writing your name when you have a mirror before you and the hand shielded so it can be seen only in the mirror. Are you successful? If so, did you trust to old kinæsthetic impressions or to the mirror picture?

3. If a child has become negatively conditioned to, *i.e.* is afraid of any small animal or event of frequent occurrence, try to remove the fear by the method of Watson.

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CHAPTER VI

LEARNING AND RETENTION OF SENSORY MATERIAL

CLOSELY related in theory and in many of its detailed laws to the more motor forms of learning we have been discussing is the acquiring, retention, and use of the sensory experiences. Stimuli always do arouse movements, and once aroused these tend to appear more frequently when the stimulation is repeated. In addition to that, however, the sensations which correspond to the stimuli also are retained and will on occasion reappear without the original stimulus. This is the fundamental fact in our purely mental life and is quite as important in practice as the purely motor types of learning which we have been discussing in the last chapter. That we recall the events of yester year is an obvious fact. That this recall is important for movement as well as for thought has been questioned recently by one school, but can hardly be denied for long in the history of thought. Most of our practical life involves more than reaction to stimuli. Many of our actions are controlled by memories and still more by reasoning. While neither of these need involve the actual response to specific images, much of it does. Without a possibility of recall in sensory form and without the guidance of actual images, our action would be very much less adequate than it is and our life as a whole much less rich. We must consider the purely conscious side of our life as well as its behaviour aspects.

Note

The Materials of Memory and Imagination. — We may begin our discussion of this form of learning on the model of the treatment of sensation. For before we can regard our enumeration of the elements of consciousness as complete, we must consider those due to the rearousal of earlier experiences. With eyes closed and other senses unstimulated, one still has conscious processes, and at all times elements not derived immediately from sense-organs mingle with the sensations. You may now recall an event of last year, although the sense-organ is not excited at all. You can see the landscape in its original colours, can reinstate the temperature of a summer day even if it is winter, may in fact renew all of its features at will. These experiences in their ultimate qualities are of the same character as the sensations. The colours are the spectral colours, the tones are the tones of the scale, the cold is the familiar cutaneous sensation. They come, however, not from the sense-organs, but are excited by the action of other central parts of the nervous system. To indicate the similarity in quality to sensation and the fact that they are due to the stimulation of one part of the cortex by another, these elementary components of memories are sometimes called centrally aroused sensations.

The Qualities of Sense Are Also the Qualities of Memory. — A little observation and reflection show that in every case these processes ultimately originate in the senses. The object that you recall is the same object that you saw last year. On occasion you may compare the memory of the object with the object itself and assure yourself of the similarity. The most noteworthy differences are that the qualities are fewer and the memory a little more sketchy than the original. Even when the image represents nothing

that has been seen before, the elements of which it is composed are of the same character as the sensations. The elements are merely rearranged in new combinations. The sensory qualities, whether peripherally or centrally aroused, like the colours upon the painter's palette, are relatively few, but from their combinations all the conscious experiences may be obtained, as the artist may paint any scene with his few colours. All the centrally aroused sensations, the elements of memory and imagination, come originally from the senses. They are retained in some way and reinstated on suitable occasion. An understanding of these centrally aroused sensations requires an answer to three questions: (1) how are they retained and where are they between the time of entrance and of their reinstatement? (2) under what circumstances do they return? (3) how do they compare in quality with the original sensations?

Note

m. B

Theories of Retention. — Theories of the nature of retention have varied, from the metaphor of the ancients that mind was like wax on which impressions might be made by a seal, to the equally crude physiological theory that each idea was stored in a single nerve-cell. The generally accepted theory at present is that retention is a physiological process allied to habit. Aristotle suggested that memories were due to the repetition on recall of the same processes movements that were made when the original experience was first received. Of course his knowledge of the physical organism was not sufficient to carry him very far in his theory, but, with allowance for our increased knowledge of the nervous system, his statement does very well to-day. Our present formulation is that memory consists in the rearousal of the cortical structures originally active, or in the reinstatement of the same activity that was in-

volved in the original experience. Whenever a nerve-tract is aroused, some change takes place in it that predisposes it to act in the same way again. What is left in the nervous system is only this predisposition to renewed activity, not an idea or other conscious process. The idea comes only on the rearousal of neurones as a result of the predisposition. Between the first appearance and the rearousal, the predisposition gives no sign of its presence. At this moment you are not conscious of the memories that might be recalled on suitable occasions. You are not at present aware, *e.g.* of the facts you learned last night in preparation for to-day's recitation, although you will be able to recall them perfectly when questioned about them.

Note

Note

The Cortical Seat of Memories. — The memories probably have their seat in the same regions of the cortex that are active in the original perception. Injuries of a sensory area usually give rise to loss or disturbance of memories, as well as to loss of the capacity for sensations. In addition, injury to associatory areas may have an effect upon remembering. It is possible that in some individuals the sense-organ is excited as well as the central nervous system, and that part of the memory comes from the retina, or from the skin where the impression was first received. The muscles originally excited by the stimulus may also be in slight contraction during the recall, may add their quota to the total consciousness. All of the structures active during the original experience may have their activity renewed in the recall. Since, as will be seen later, the order of occurrence determines the order of recurrence, it seems probable that the connections formed at the original experience make possible recall and that the change in the nervous system is in the synapse, where neurones meet.

Retention a Form of Habit. — In this, retention is closely related to habit. Habits, as was seen, are due to the establishment of connections between sensory and motor neurones by a change that takes place at the synapse. After these have been connected frequently, the stimulus tends to reinstate the act whenever it appears. Retention of ideas has exactly the same basis. The cells involved in the ideas also act together, and this activity produces changes in the synapses. Whenever one of the ideas presents itself again, the other is, or tends to be, reinstated. Not merely the cortical elements are rearoused in memory, but the whole sensori-motor tract may be partially active. This brings the process still nearer to habit. Memory is an habitual response in which the greater part of the activity is in the cortex. The activities of the sense-organ and of the muscles are subordinated to the central processes, while in habit all parts of the sensori-motor tract are active in approximately the same degree. The tendency to repeat a movement once made, or the tendency for neurones that have once been active together to act together again when either is aroused, is at the basis of both processes. Thus, when a stranger enters the room, I stand because the sight of a stranger has been closely connected with rising. But at the same moment I recall vividly a remark, made on another occasion, by a person of similar appearance. This remark has been connected with the sight of a person of this description, in very much the same way that the act of rising has been connected with the entrance of a stranger. The thought might have been spoken and, then, that also would have been a habit. The only difference when it is merely recalled is that motor accompaniments are omitted. N.B.
In all else it is as much a habit as any movement.

After-Image, Memory After-Image, and Memory Image. — Retention may also be related to the visual after-image. The after-image is the effect of a stimulus upon the retina that persists for a short time after its cause has ceased to act. Cortical cells show a similar tendency to continue in action for a period. If you will glance out of the window for a moment and then close the eyes, you will notice that the objects you saw during the momentary glance persist for a few seconds with sufficient definiteness for you to note details that escaped you during the actual observation. This mental photograph has the same explanation as the positive after-image. Like the after-image, it is the result of the persistence of activity in the neurones when the stimulus is removed. It is sometimes called the memory after-image or primary memory, or more recently the perseveration tendency. In certain individuals these memory after-images persist for a very long time and may be projected as real sensations are. In fact they may be mistaken for objects. Jaensch of Marburg who has studied these individuals carefully finds that almost all children have a tendency to these more vivid images. He called them eidetic images, and the individuals who have them 'eidetikers.' The ordinary memory, or reinstatement after the primary memory has lapsed, may be looked upon as a renewal of the same activity of the cells induced by the stimulus that persists during the primary memory. Note To-morrow when you recall what you saw as you looked from the window, you will induce in the cortical cells the same sort of activity that they showed when you were looking and during the memory after-image.

Recall Always through Associated Experiences. — The answer to our second question, how centrally aroused experi-

ences are recalled, is found in the laws of association. These laws assert that all recall is due to the preceding mental process. This process is effective in calling back the ideas because of connections developed between them at some earlier time. The idea that was in mind a moment ago and the idea that it suggests now must have been experienced together at some time, if the one is to recall the other. The initiation of recall by these earlier experiences and connections may be seen in any train of ideas. If one records the elements of an uncontrolled train of thought, it is seen that each element is connected with the following by virtue of the fact that both have been experienced together at some time. A girl passing my window suggests the house I saw her going into yesterday. That suggests the stages in building the house; that, in turn, the sound of hammering that woke me this morning; and this again the protest of one neighbour to another who had been frequently chopping kindling wood at an unreasonably early hour in the morning. A revery of this sort, when started, may run through successive links until disturbed by some duty or other distraction. A study of a train of ideas will show that each member of the train has been connected with the preceding and succeeding links at some earlier period. It is evident, however, that in the series just described, the connections are of different sorts. In the first two cases, recall is due to the earlier simultaneous presentation of two events. In the last instance one factor, the sound of hammering, is common to both experiences and recall seems to be due to a shifting of connections about that. Both types must be taken into consideration in classifying and explaining instances of recall.

Note

N.B.

The Laws of Association. — The traditional classification

of association has been traced back to Aristotle. It recognizes four laws: association by contiguity, by succession, by similarity, and by contrast. This is merely a descriptive classification. The first two types in the classification are named from the time relations of the events that become connected at the time of the first occurrence. In association by contiguity two objects present themselves together; in association by succession one follows the other in the first experiencing of them. If A and B have ever been experienced together, either is likely to recall the other. If B follows A once in experience, it is likely to be recalled by it again. Association by similarity and by contrast are named from the degrees of similarity or opposition of the ideas that succeed each other in recall. If the idea that comes first is like the idea it recalls, we have association by similarity. When the idea suggested is opposed in quality to the idea that recalls it, as black to white, the association is said to be by contrast. In the illustration of the preceding paragraph, the girl suggests the house because I have seen them together. The most familiar instance of association by succession is found in rote learning. Words repeated in succession return in the same succession when one of the series presents itself. Association by similarity is illustrated above by the sound of hammering suggesting the protest of the neighbour against early morning noises.

The Neurological Theory of Association. — If we turn from the description of recall to ask why one idea should arouse another, we must turn to the nervous system. In its terms our law is that if two neurones are active simultaneously or in immediate succession, some connection is established between them of such a character that if one be

excited in any way, the excitation spreads to the other. The point of connection is, as has been said frequently, the synapse. It is as if two simultaneously active parts of the cortex started each a nerve current towards the other or each active group of neurones drew an impulse from all other active groups of neurones. This assumption we saw in essence to be necessary to explain the formation of the conditioned reflex, and we may apply it here. No matter how far the two active groups may be separated in the cortex, the impulses seem to find a way from one to the other. The passage of the nerve current from one to the other increases the permeability of the synapses between them so that for a time afterwards, whenever one of the two groups is excited, the excitation spreads across the intervening synapses to the other and arouses that to activity. Note

This is different from the explanation of habit in that habit always involves the passage of the impulse from a sensory to a motor neurone and action always results. Here each stimulus may tend to arouse a reflex of its own, and the connection between the sensory neurones is in addition to that. Here, too, the excitation of two neurones at the same time or in close succession decreases the resistance of the synapse. This increased closeness of connection makes possible the spread of any activity from one to the other. When one learns the first letters of the alphabet, the impulse spreads from the neurones corresponding to 'a' to the neurones corresponding to 'b,' and as a result of numerous repetitions the two groups grow together to such a degree that whenever 'a' is suggested, the excitation spreads to the neurones that correspond to 'b,' and they are excited also. The change in the synapse as a result of use is the explanation of association, as of habit. Asso-

ciation by contiguity and succession is the expression of this simple and familiar neurological function.

Association by Similarity. — Not so immediate is the explanation of association by similarity or by contrast. Neither similarity or contrast is itself a force, nor is it possible to find simple physiological correlates for them. (The ordinary idea is not a simple element of consciousness but is a complex of many centrally aroused sensations.) (The mechanism of recall consists in replacing certain of the elements of the first idea by others to constitute the new idea. Thus the replacement of the idea of the disturbing hammering, by the idea of the neighbour's protest at another form of disturbance under the same circumstances, may be regarded as due to a shift of ideas about 'early-morning-noise-that-disturbs-sleepers' as a center. The elements that have to do with hammering in building the house drop out, and the persisting elements that constitute the early morning disturbance idea are retained. These by the law of contiguity or succession waken the remaining elements of the incident described by my neighbour. The common element at once makes possible the entrance of the second, and gives similarity to the two ideas. If this be translated into nervous terms, the first idea corresponds to the action of a considerable group of neurones. The shift to the second idea consists, first, in the cessation or diminution in the activity of certain elements of the mass, while others continue to act with full intensity. (The cells that continue active rouse to activity the other group of cells with which they have also been active earlier, and with that the incident of the protest against chopping in the early morning comes to consciousness.) The simple physiological laws are the same here as in association by succession; the

only added feature is the dropping out of some elements, while the others continue active. Wundt has called this sort of recall association by identity, since it is the identical element in each idea that determines the course of recall. James calls the process focalized recall, but both agree on the essentials of the process as given above. Association by contrast, too, is to be explained as one case of similarity. Only objects that stand at the opposite poles of a common quality contrast. White does not contrast with rich, nor large with beautiful. Certain cases are to be referred to contiguity or succession, for contrasts are noted only when the objects are together. Neurologically it requires no special explanation.

Units for Thought, Complexes for Neurology. — Both sorts of association involve the same principle, but there is a slight difference in its application. This is, that use tends to connect neurones, or that mental elements which appear together tend to return together. The apparent difference between the two classes serves merely to emphasize the fact that ideas are neurologically and psychologically always complex. The ideas that are recalled by contiguity or succession are not simple, but the mass of elements may be regarded as disappearing or appearing as a whole rather than as dissolving one into the other, as in the so-called association by similarity. In both cases one must distinguish between the unit for thought and the unit for physiological action. For thought, the idea is the unit; one is concerned only with things and with their representatives as wholes. Association on the contrary is always between the elements that correspond to the activity of neurones. Their connections alone determine the way in which ideas shall succeed each other, and how they shall dissolve, one

into the other. The older laws of association considered only the relations between the ideas as wholes; any dynamic explanation must consider primarily the connections between the elements. They explained by similarity what the more modern men explain by the shifting of associates about some persisting element as a core. Both are true, but one is a description of the ideas after the recall, the other is the real explanation of the recall. In general the more mechanical operations, rote learning, etc., involve contiguity and succession, while the more intelligent forms of thinking make the association by identity more prominent.

N.B.

How Memory Images Are Distinguished from Sensations. — The elementary qualities of memory, imagination, and reasoning are very similar to the qualities of sensations. If one thinks of a red surface, one may have an image in every respect like the original perception. The colour is red, the texture of the surface is the same as the texture of the object. Although the qualities are the same as in sensation, there are nearly always sufficient differences to prevent one from mistaking a memory image, or image of imagination, for the real object. Three important differences serve to distinguish memory image from sensation. These are: (1) centrally aroused sensations are ordinarily less intense than the real sensations; (2) they have certain characteristic qualitative differences; (3) they do not harmonize with the objects that are seen at the moment. The first criterion is ordinarily sufficient, but fails when the images become very intense, or the external stimulus is very faint. Such great vividness of the images comes only rarely and usually in abnormal individuals or under abnormal conditions. Faint intensity of external stimulation may be obtained at will. In a series of experiments by Külpe, individuals were

seated in a dark room and were told that at a given signal coloured lights might be thrown upon a screen. Sometimes these were shown and sometimes not. They were asked to say whether the resulting experience was subjective or objective and also to state how they distinguished the real colours from those merely imagined. Under these conditions, every observer made mistakes. Ordinarily the mistakes consisted in asserting that colours were seen when none were shown. The merely imagined qualities were mistaken for objective qualities. When questioned as to how they distinguished one from the other, the observers gave a list of the characteristics that aided them. The subjective processes were indefinite in outline, were thin or netlike, they moved at random, they persisted when the eyes were closed and moved with the eyes, they left no after-images. The real sensations were definite in quality and outline, vanished on closing the eyes, remained stationary as the eyes moved, and left after-images. The differences are on the whole insignificant, and even those that were mentioned were not constant for all individuals. In quality, images are not very different from sensations.

More important as a means of distinguishing one from the other in practice is the harmony of images with the preceding train of thought, and their lack of harmony with the events of the outside world. If one should look up suddenly and see what appeared to be the figure of a person known to be remote but whom one had been thinking about just before, one would at once appreciate the figure to be an image. This would be all the more certain if no footsteps had been heard, and the wall could be seen through the image. The figure would be seen to be a natural result of the thought processes but altogether out of harmony with

the external events. Reference of a mental process to a central or peripheral origin is most frequently made in terms of the degree to which it fits into the train of events, although intensity and the peculiar penetration or vividness of the sensation nearly always contribute their share.

The Projection of the Memory Image. — A third criterion is often furnished by the direction in which memory images are projected. For some individuals the image will be directed backward if centrally aroused, as opposed to the ordinary outward and forward reference of the real visual sensation. Objects when recalled may be seen as if they were on a surface some distance back of the head. Others project imagined objects to the right or to the left. Here they will not be confused with the sensory impressions. It is possible that images can be projected outward and forward so as to have a position among objects actually seen. One individual always sees remembered or imagined events projected in colours upon the wall of the room, and many can give these images any desired position in the visual field. These are mere personal idiosyncrasies. Where the central processes are thus habitually given a direction different from that given sensations, the direction is a result of the distinction that is made, rather than a means of distinguishing them from external objects. The decision as to whether the process is of external or internal origin is practically always immediate and without hesitation; one does not even appreciate that a decision has been made.

Memory Types. — While the memory images are in general like sensations, they certainly have fewer qualities. The number of pure colours that an individual can recall is probably limited to a dozen or twenty, as compared with

the one hundred fifty or two hundred that may be discriminated in the spectrum. The qualities in the other senses are similarly limited. Not only are the remembered qualities of any one sense relatively few, but most individuals are restricted for their memory material to two or three, and a few to but one of the senses. Most numerous are the individuals who remember in visual terms. A visualizer of the exclusive type will recall only the pictures of objects. As he thinks of the water running from a faucet, he can see the water fall, see it splash, but has no trace of the sound. The whole event is noiseless in memory. Everything that he remembers must be translated into pictures. More rare is the auditory memory. Individuals of this type lack all but the sounds in any memory process. An event will be recalled only in terms of the sounds that were connected with it. In other individuals, memories are restricted to the movements that were made in connection with the events. These movements may be memories, or the movements may be partly reinstated. One might translate the sounds of the voice that one desires to recall, *e.g.* into the movements necessary to imitate them and so represent the voice to himself. Smell, taste, and the other lower senses alone would not suffice to recall all sorts of experiences; where present at all in memory they are subordinate to one of the forms of imagery just mentioned.

visual memo

audi. mem

motor memory.

Verbal Imagery. — Again, almost all experiences may be recalled through language. Practically every experience may be and is expressed in words, and most individuals use words very generally in thinking as in talking. Much of thought is anticipatory speech. This form of reproducing or imagining is known as 'inner speech.' Verbal imagery might conceivably be present in the form of words heard,

auditory-verbal imagery; of words felt as if they were to be spoken, motor-verbal; or of words as seen in print or writing. As a matter of fact verbal imagery is mostly either auditory- or motor-verbal. It is too closely connected with the pre-reading age for the visual elements to be very prominent. There is little connection between the concrete and the verbal imagery for most individuals. One may be visual in the memory of concrete objects while one's verbal imagery may be either motor or auditory.

Memory Types Usually Mixed. — The traditional treatment of imagery states or implies that these types are mutually exclusive, that if an individual has a well-developed visual memory, he will not have auditory images, and *vice versa*. Recent results indicate that while this may be true for the occasional man, usually for the older men who have become well set in habits, most individuals have more than one sense represented in imagery. The same individual may have command of all of the senses in recall as in perception. In each instance, he will employ the imagery best adapted to the event. Most persons use two or more different forms of concrete imagery and nearly all in addition have a memory in words. The words may be recalled in a sense different from that used for concrete objects. Thus one may recall a landscape in visual terms, but think of the forces that moved the rocks in words presented in auditory or motor terms. There are also marked differences in the degree of clearness in the type of mental imagery that is generally used. Of dominantly visualizers some can picture objects clearly, some only in general or vague outline, and it may happen that a man who uses visual imagery predominantly may not picture events so clearly as another for whom auditory imagery is dominant.

Imagery and Practical Efficiency. — Obviously, there must be a fairly close relation between the accomplishments of the individual and his memory type. It would be very difficult to imagine a painter who could not recall colours and forms, or a musician who had no memory for tone. As a matter of fact, most great musicians are of the auditory type and most painters are visualists. In more commonplace affairs the memory type plays an important part. A pupil who has little or no visual imagery finds difficulty in spelling. It should not be supposed from this that powers of observation are similarly restricted. One of the visual type may understand a lecture fully as well as his fellow of auditory mind; as he understands, however, he translates what is said into pictures and remembers these. Recognition of the voice may be as accurate, also. The visual-minded individual will know the voice of a friend when he hears it again, although he may not be able to recall it at all. Apparently, memory types may be trained, and undergo changes with age. Experiments in developing memory types that were originally weak have met with some success, although the course of training must be long. Imagery tends to become less concrete and definite with advancing years, particularly if the individual devotes himself to pursuits requiring abstract thought. The very vivid images of the so-called eidetic type (p. 161) usually disappear in the teens. Galton found that English men of science had very little definite imagery. Most thinking was in words or in other more abstract forms of thought. It seems that the general tendency, as men deal more and more with principles and less and less with particulars, is toward a disappearance of detailed imagery, and its replacement by symbols. The objects are represented in memory by

imagery that has less and less resemblance to them, but which is better adapted to the needs of quick and accurate thought. Language most frequently replaces concrete imagery in this reduced form of thinking.

Summary. — Our next fundamental mental fact is that N.B. impressions received from the senses are retained in the nervous system as dispositions to re-excitation. They return when some experience that has been connected with them precedes them in consciousness. When these dispositions become realized, they constitute the elements of memory, imagination, and reason. They are similar to the original sensations, although much poorer in the number of distinguishable qualities. In the representation of things, not all the elements of the original object need be present. One or more sense departments may predominate in recall to the exclusion of others. next Thursday.

QUESTIONS

1. What are centrally aroused sensations? What are the common names for some of the concrete processes which they constitute?
2. How are experiences retained? Are they retained as ideas or as nervous effects?
3. Can you see any relation between the nervous basis of retention and the nervous basis of habit?
4. What is the perseveration tendency?
5. How far are the 'laws of association' explanations and how far mere classifications?
6. What is the fundamental neurological process in association?
7. How can one explain association by similarity in nervous terms? association by contrast?
8. How does 'primacy' affect retention and recall?
9. How do you distinguish between a memory and a real object as you see it? Which is centrally, which peripherally aroused?

EXERCISES

1. Trace the similarities and differences between an after-image, a memory after-image or primary memory, and a memory image. Look at a bright object for ten seconds. Close the eyes and describe or note the after-image. Take a momentary glance at the same object and note the memory image of the object that is obtained. Compare it with the after-image for clearness of outline and quality. Recall some similar object that was seen yesterday and compare it in every respect with the other two. How are the three processes related nervously?

2. Let your mental stream flow at random for half a minute. Write out the ideas that come to you in the order of their appearance. Can you trace the order to earlier connections of simultaneity or succession? Are there instances in which one idea dissolves into another? Classify the associations in accordance with the text. Are the simple or the complex associations more frequent?

3. In the list above, mark the connections due to primacy, to recency, to intensity, and to frequency.

4. (*a*) Read the book designation on one card of the library catalogue and go to the shelves to find the book. In what form of imagery do you keep in mind the designation?

(*b*) Read the book designations on two cards and repeat the experiment. Is the imagery the same?

5. Recall the last public lecture that you attended. Can you see the speaker? Can you hear the words that he speaks? Can you recall in any way the peculiarities of his voice? How? Can you reproduce the pressure of the programme that you held in your hands? the strain from an uncomfortable position? Do you have distinct memories of taste and smell? Can you grade the clearness of the memories from the different senses?

6. Do you project your memory images in the same direction as your sense impressions? For instance, do you think of the speaker in the preceding exercise as in front of you, or behind, or to the right? How large do you think the speaker to be in your memory projection? Do the objects have the same colour and the same background as the actual sensations? Do you ever mistake a memory for a real object? Why or why not?

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CHAPTER VII

ATTENTION

Attention as Selection. — By attention we mean a readiness to receive impressions of a given kind and to eliminate all others. A teacher demands attention before beginning a lesson. Before that the students may have been devoting themselves to all sorts of impressions and various memories. When attention is given to the teacher all this is stopped, and the way prepared for hearing what she has to say. The military order carries with it the same readiness to receive commands. With this readiness goes silence, and in the military a fixed position. Accompanying this on the mental side is the dominance of some one idea in consciousness and so a greater clearness, a greater effectiveness of that idea. With this go motor processes and various incidental mental effects which we shall discuss in the course of the chapter. As in the last chapter, we could treat instinct together with earlier habits as the determinants of selection between reflexes, so here we may consider under the head of attention the various factors that impel to the selection of sensations and ideas.

Omnipresence of Selection. — Selection is one of the most striking functions in the mental life, which we see applied to sensation or the memory and thought processes as well as in the control of behaviour. Were there no selection a man would be absolutely dominated by the environment for his perceptions. The most intense sensa-

1. accompanying things.
perception - the becoming aware of objects in the world without.

tion alone could affect him. In recall, the synapse that was most open must alone lead to the recall of a memory, or to a rational conclusion. As it is, there is a much more delicate control. We express this popularly by saying that the man is not under the complete control of the stimulus of the moment, of the strongest tendency to recall, any more than he is of habit in action, important as these all three are. He can decide for himself, within limits, what he shall hear or see, what he shall think or what he shall do. He may admit faint stimuli to consciousness while stronger ones are acting upon the sense-organs; he may repress a strong habit and permit a weaker one to run its course; or he may choose a faint memory when several that are ordinarily more insistent are pressing for return. Evidently, selection is of fundamental importance in perception, in action, and in memory. Since selection affects so many different processes and has so many different phases, it becomes necessary to distinguish between the questions that may be answered in the same way everywhere and those that must be treated differently in each field. Three questions must be answered in connection with each kind of selection: (1) what is the effect of selection upon the process affected? (2) what determines the course of selection? (3) what are the concomitants of the selective activity? Of these the first takes different forms in each field; the second and third are general, — an answer in one connection will hold with little change for both of the others. The conditions of selection and the means of knowing that selection is being made are the same for perception, for memory, and for will. In this chapter we shall discuss primarily attention or the selection of sensations and ideas but we shall also point out the similarities between the

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attention processes and the control processes in thought and action.

Effects of Attention on Sensation. — The general effects of selection are the same for perception, for thought, and for action. One reads on a railroad train in spite of the noise and other distractions; one hears the faint sounds of a conversation in a storm or in a boiler shop and are for the moment not aware of the din. When studying attentively, one may be spoken to several times without being disturbed. Similarly, one can continue a train of thought even when other very pleasant memories suggest themselves or in the midst of external disturbances. A stimulus that has given rise on different occasions to a number of different responses and might now be the means of exciting several different movements will arouse but one of these, — that one will be selected from the other possible ones. Each of these selections is of the same kind. One process is given free rein; all others are checked.

More frequently in attention to external stimuli, the processes not selected are not absolutely excluded from consciousness, but are given a subordinate place. As one attends, certain sensations are clearly appreciated; the others are less clear. One of the much discussed problems of attention concerns the difference between the sensation directly attended to and the others that constitute the background of consciousness. Two conflicting theories have been held: one, that attention increases the intensity of the sensation, the other, that the change is peculiar and must be given a different name, clearness. All agree that the effect of attention is similar to increased intensity. Both make the sensation easier to describe, make all judgments about it more accurate, and give it a more important

place in consciousness. But the two effects must be different in some way, for one seldom mistakes a change in attention for a change in the intensity of the stimulus. It is not assumed that the violin has increased in intensity when its tones are picked out from the mass of an orchestra, nor is it assumed that the tactual sensations grow weak when they are not attended to. It is certain that attention and intensity are sufficiently different in their effect upon consciousness to prevent them from being mistaken for each other. It is generally asserted that attention increases the clearness of a mental state. The state becomes clearer, its details are more prominent, it can be more easily used and understood. This quality of clearness is, however, different from intensity in spite of the fact that both make a mental state more important.

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Analysis and Synthesis. — Analysis and synthesis may both be referred to the effect of selecting different states. In analysis some one part of a total process is made important, and this renders possible the recognition of its constituents. As one attends to one of the notes of a chord, that note becomes prominent in the complex. Analysis of the chord consists in making each of its components stand out one after another. Synthesis is also a result of increasing the clearness of mental states. It differs from analysis only in that the total effect of the mass is attended to rather than some one component. With the chord one may attend to determine the closeness of fusion of the components or the pleasantness of the compound. This serves to unite the elements into a single whole. The results of attention may be either to analyze or to synthesize, but in either case the primary effect is to increase the prominence of a part or of the whole. This change in clearness with

the resulting analysis or synthesis may affect memory or thought processes as well as sensations. One may analyze either the memory or the sensational elements from a perception, or one may turn from a perception to study mental imagery, or may attend to one part after another of an idea. The effect upon ideas is the same as upon sensations. In action, selection is more likely to be of wholes than of parts, although on occasion one element of a complex act may be emphasised without changing the others.

The Conditions of Attention. — Why one selects or attends is not so easy to determine. Usually the conditions are hidden. Attention comes without antecedent desire or warning. One often finds one's self attending without any preliminary intention and even against one's will. When one desires to attend, in advance of attention, it is a problem why one desires, and this usually escapes notice even when the question is raised. Nearly always one is concerned to know only that one desires to attend and does not care to know why. Indirect methods, however, have thrown considerable light upon the conditions of attention. These methods consist in studying the circumstances in the individual and the outside world that precede attention, and in generalizing the results of the observation in laws. In the light of these observations two sets of conditions may be distinguished, the subjective and the objective. The one is a series of circumstances in the outside world that precedes attention, the other the earlier experiences of the individual. These conditions may be first determined for attention to external stimuli, although the results hold for all selection.

Objective Conditions of Attention. — The circumstances in the outer world that favour the entrance of a sensation

are to be found in the amount of energy exerted by the stimulus upon the sense-organ. The amount of energy expended may be due to the intensity of the stimulus, to the area of the sense-organ affected, or to its duration. (1) Intense sounds such as explosions, bright lights, strong odours, will force themselves upon attention, however much one may desire to attend to something else. (2) Large objects are seen where small ones escape notice. Advertisers spend money for a large space when they might say all in a small one. Experiments on advertisements, however, indicate that likelihood of attracting attention increases only as the square root of the area rather than directly. (3) Increased duration of a stimulus tends to increase the chance that it will be noticed. This third law holds only to a certain point. If the stimulus continues too long we become indifferent to it and it is no longer appreciated. This implies another condition of attention, possibly the most important of all, (4) change. One notices a whistle of changing pitch or intensity where a constant one would escape notice. One even appreciates the ticking of a watch as it stops, although the preceding continuous ticking has not been noticed at all. Similarly, objects that move towards or away from us are noticed, although the same objects would escape notice if stationary, and our only way of knowing that they move away or approach is from the changing size. Change, whether in size or intensity, whether it be increase or decrease, attracts attention. Closely related to duration is (5) repetition. A faint stimulus once applied may not be noticed. Let it act again and again and it produces an effect. This also is proved by study of advertisements as well as by less complicated experiences.

Objective or in Nervous System. — One might question whether these conditions were an expression of the mere physical intensity of the stimulus or were dependent upon the fact that the nervous system tended to let nerve impulses aroused by stimuli of great intensity, large size, or long duration, or stimuli frequently repeated, pass across its synapses while others did not. It matters little. All these are expressions of physical force and it is hard to conceive a nervous system that would not give them preference. The effect of change is not quite so obvious and to explain it we may be compelled to call upon instinct, or the failure to survive, of animals that did not notice change. (On the whole, these characteristics of the outside world which tend to compel us to receive a sensation may be said to be opposed to attention) They express, not the selective activity of consciousness, but the forces in the outside world that oppose voluntary selection. If they alone acted, consciousness would be but a plaything of external forces. It is usual to extend the meaning of the term attention to cover all the factors that explain the entrance of sensations, and one cannot understand the subjective factors without a knowledge of these objective conditions, whether one calls them conditions of attention or not. One might add in this connection, in anticipation of the later discussions, that there are similar objective conditions which oppose subjective control, both in memory and in action. In both, these are found in the closeness of connection between sensation or idea and other ideas or movements. The development of the laws must be left to the later chapters.

The Subjective Conditions of Attention. — The subjective conditions give the individual what we call spontaneity and self-expression in the selection of sensations. Even

this apparent spontaneity can be reduced to certain laws, however. They reflect the earlier life of the individual in very much the same way that the objective conditions reflect the outer world at the moment. It is possible to enumerate five factors of greater or less generality that determine the nature of attention. Enumerated in the order of nearness in time to the particular act of attending, these are: (1) the idea in mind, (2) the purpose or attitude at the moment, (3) the earlier education, (4) duty (as the expression of social or individual ideals), and (5) heredity. The first can be seen either in the influence of an immediately preceding sensation or of an immediately preceding idea. If one has heard or seen or is thinking of some object and that object presents itself, it will be noticed where otherwise it might escape attention. It is easier to hear an overtone if a tone of the same pitch has been heard at full strength just before. Similarly, in listening to an orchestra, recalling the tones of a violin or looking at the violin will be certain to make the tones of that instrument prominent, when otherwise they might not be noticed. If when looking for an object one will hold its picture in mind, one will see it at once. When a bird in a tree has been seen once through a glass, it will continue to be seen easily, although it may have been looked for in vain a long time, before it was first discovered.

idea in mind

A Condition of Attention. The Question. — The second of the subjective conditions of attention takes three forms. Each is an expression of a mental attitude and is a little more general than the idea or sensation prominent at the moment. The most usual and most definite way of arousing the attitude is to (1) ask a question. This may be illustrated by a simple experiment. Cut a number of bits of

purpose or attitude

paper of different shapes and colours. Cover them with a piece of cardboard and expose them for an instant as you ask, 'What colours do you see?' After exposure the observer can tell pretty accurately what colours were shown. If then you ask him what the forms were or how many bits were shown, it will be found that he can give no correct answer. One sees what corresponds to the question; all else is excluded from consciousness. Sometimes the question arises spontaneously or is suggested by a sensation. You wonder if it is raining, and as you look out of the window with this question in mind, you notice a drizzle or see spots upon the roof that would otherwise have escaped you. Very many observations grow in this way out of specific questions, and it is surprising to note how certain the question is to bring to mind any object that may contain the answer to, or correspond to, the question, and how little one sees that does not correspond to some question. Most people cannot say whether the numerals on the watch are arabic or roman, because they look to learn the time, and have no interest in the characters.

Purpose as a Condition. — Next in order of explicitness of conscious anticipation is the purpose. This differs from the formulated question only in that the end to be attained is less definite or less definitely formulated. Often one first has a vague general problem and this suggests one definite question after another and these in turn control the specific acts of attention. Usually one has some definite purpose in observation as in action, and this serves to control attention even when there is no definite question in mind. In a laboratory one may be seeking for the solution of some problem with no definite question formulated. Under those circumstances one is very likely to notice anything

that harmonizes with the purpose. Similarly one notices animal life in the field of a microscope more easily in the zoölogical laboratory, and plant structures more easily in the botanical laboratory. The purpose is not very insistent in these cases but is none the less operative. In everyday life what is appreciated corresponds very closely to the purpose, whether that purpose be serious and permanent or trivial and transitory. On a hunting trip one is set for the perception of game, as in a classroom one is set to understand a lecture or hear a question. This 'set' constitutes the purpose, and is effective even when not kept in mind.

General Mental Attitudes and Attention. — One often has still less definitely conscious 'sets.' In these one is not aware of a purpose and has no definite question. The bias arises from some previous experience and is not preceded by a desire to see one thing or group of things rather than another. Nevertheless any object that corresponds to the attitude will be noticed at the expense of other objects. After one has detected escaping gas, other odours often will be noticed, even after all thought of detecting an odour has vanished. All three of these factors serve to quicken attention for one group of things rather than for another, and together they constitute its most important condition. What does not correspond to the attitude, purpose, or question of the moment is not admitted to consciousness, and all that does correspond to it will be noticed, no matter how unfavourable the circumstances in other respects. Practically the only difference in the three sorts of attitudes is to be found in the degree of anticipation of the object attended to. The question very definitely foreshadows the object to be seen; the purpose gives only a general idea of the class of objects to be expected; while the attitude is not at all

conscious and gives no expectation. The attitudes change from hour to hour, and even from moment to moment. They are practically the only occasions for the shifting of attention.

Education as a Condition of Attention. — The influence of the earlier life in determining the general character of attention is as marked as the influence of the attitude in the changes of its temporary character. Two influences of education may be distinguished. (First it makes certain forms of attention more effective.) The skill of tea and wine tasters, the keenness of the savage for following a trail are due, not to any improvement in the sense-organ through practice, but to training in attention. In every sense department and in every sort of observation one comes with practice to appreciate differences that at first cannot be detected. (One important result of any sort of edu ation is the increased capacity for observation.) (A second influence of education upon attention is the more usual one of determining the stimulus to be effective) What is seen or heard is usually an indication of the character of earlier experiences. If a man enters a strange room, he will notice first some object which his education has prepared him to see. A fisherman will notice the rod on the wall, the athlete the mask and foil or the lacrosse stick, the scholar will see the books, and the artisan the implements of his trade. It is possible to make a fair guess as to what a man's occupation or training is by studying the objects he observes and the order in which he sees them. Even more generally one will hear one's own name when spoken in a conversation of which nothing else is heard. Sometimes education acts indirectly by preparing questions and purposes; often education acts directly — one is not

aware of any preliminary purpose. In brief, education gives capacity for discrimination and also determines the order in which presented objects shall enter consciousness, and whether they shall enter at all.

Social Determinants of Attention. — One effect of education upon attention is important enough for separate mention. This is the effect of social training which serves to hold attention to the momentarily unpleasant for the attainment of future benefits. One is constantly being taught that certain things must be attended to in spite of the fact that others are more in harmony with the momentary mood. It is of course not possible to analyze, in their completeness, the forces that make for this sort of attention, but so far as they can be analyzed they may be referred to social influences and be brought together under the term social pressure. One ordinarily works for the object at present less pleasant to gain some greater remote good. The value of the remote good is learned from and usually enforced by society, and enforced as a duty, not as a good. The impulse to work for it is given through ideals, and the ideals can be traced to the society of the individual. The boy of to-day seeks to avoid manual labour and to enter the professions, even when they are relatively unremunerative, because of the small esteem in which working with the hands is held by society. Each ideal demands for its attainment holding attention for a long time to matter that is not pleasant. When you turn from reading a novel to this chapter, you are governed by social pressure. First is the pressure exerted by teacher and class to stand well, and then the desire to attain the end for which this knowledge is a preparation. Both ends are desirable in the last analysis because of the social approval they receive. The punish-

ment of failing to attend is social contempt; the reward of persistent attention is social approval. Society sets the end, social pressure compels one to attend for its attainment. The attention that comes from social pressure is distinguished from the other forms of attention due to education in that the end and the process are unpleasant, and attending seems to be the result of effort, while in the others the end and process are pleasant and are interesting.

Heredity and Attention. — To understand certain characteristics of attention we must go back of the experience of the individual to his original nature. This is determined first by the evolution of the race and second by the immediate heredity of the individual. The first explains the fact that all are attracted by movement and by individuals of the opposite sex, and that love stories and stories of fighting universally hold us. These fall under the head of instincts and have been discussed in the preceding chapter. Under the second fall the differences in taste shown by individuals. Liking for music or art goes back in part to a tendency to observe certain stimuli rather than others. Many similar characteristics and capacities must be explained in large part by innate differences in attention. It is still impossible to say how far any particular act of attention is due to an hereditary influence and how far to education and other acquired tendencies. Certain it is, however, that each is important.

The Control of Ideas. — Not only what shall enter consciousness from the outside world, but also what shall be recalled through association is subject to control. In the last chapter we spoke as if only the mechanical connections earlier established at the synapses between neurones decided what should be recalled. This is quite as far from the truth

as to assume that the stimulus alone determines what shall be appreciated. Were the strength of connection the only determinant of recall, it would be possible to think one thing only after thinking of the other idea that was most closely connected with it. As a matter of fact, one finds that recall is much more flexible. We have to regard these physiological connections as important, but to them we must add a group of factors similar to those just shown to constitute attention. We can regard the causes of any recall to be in part the strength of the connection between the separate elements, and in part the expression of the action upon the particular element of the immediate setting at the moment and of the wider relations to other experiences, past and present. We may call the two sets of conditions again the objective and the subjective. here.

The Objective Conditions of Recall. — Among the more mechanical factors, corresponding to the objective conditions of attention, we find the influences that determine the strength of the connection between the neurones. These are four in number: (1) the strength of the original excitation; (2) the number of times the two have been active together; (3) the recency of the original connection; and (4) primacy, whether the connection was formed in early life or later, since a first impression makes stronger associations than later ones. The intensity of the original excitation depends upon three factors: (1) upon the intensity of the physical stimuli that gave rise to the original experiences; (2) upon the degree of attention that was given at the time; and (3) upon the emotional condition of the individual at the time of learning. Your own experience will convince you that each of these has an effect. Two weak experiences will be less likely to be associated

than stronger ones. Much more important is the effect of attention. Inattentive reading is only slightly effective. Attention at the moment of the original reading may make faint impressions more effective than intense impressions to which no attention was given. In fact, it might be questioned whether the intensity of the stimulus had any effect, except as it served to attract attention. The effect of emotion is very closely related to attention. If the original experiences are accompanied by marked emotion, the likelihood of recall is increased. The remainder of the objective conditions of recall require little comment. The strength of the connection grows regularly with repetitions, and falls away with the lapse of time. Of two associates, the one first made seems to have an advantage over the other. This is one explanation of the fact that events of childhood are more frequently recalled than those of later life. Each of these objective conditions is effective, because it helps to determine the strength of the connection between the different neurones.

Selection by Subjective Factors. — While these objective or physiological connections are essential to all recall, and play an important part in controlling the selection of one from many associates, they cannot be the only determinants. Were they the only factors in the selection, the course of thought would show no flexibility and no spontaneity. Only one associate can be physiologically strongest at any moment. In actual experience we have an idea recalling now one idea and now another; we are ever and anon preferring a faint associate to a strong, an old to a new. What gives this variety and flexibility to ideas is the group of subjective conditions. These are practically the same as the subjective conditions in attention. The first

is the purpose of the moment. If you are solving one problem, the associates that are suited to that problem will be recalled; if you are solving another problem and have the same idea in mind, it will recall another idea. For example, if you see in your account book two numbers written one above the other, you will add in one case, you will subtract in the other. Whether you add or subtract will depend upon the problem that is set you by the earlier stages in the accounting. If you are dealing with two expenditures, you add; if dealing with a balance and an expenditure, you subtract. In this case, the sum is one idea that the two numbers might suggest, the difference, another, and which shall enter depends upon the purpose of the moment. Similarly, if you read a series of adjectives to a person with the request to name opposites, you will get one series of associates; if you ask him to give synonyms, you will get another series. Here you set the task, and it leads at once to the right associate.

Attitude Controls Association. — Very similar in effect is the attitude. This differs from the task or purpose in that it is not at all conscious, is not appreciated by the thinker. When asked in a class in psychology what is a sensation, one at once thinks of the psychological definition. The same question by a child who was reading the headline of a newspaper brings to mind an entirely different answer. One is not aware of the psychological attitude, but it is suggested by the place. The sight of the newspaper gives the newspaper attitude certainly and unconsciously. James illustrates the influence of attitude by the effect of the context in two lines of verse. The same word, when it occurs in different lines, will recall different associates. Thus the word *ages* occurs in the two lines from Locksley Hall:

'I, the heir of all the *ages*, in the foremost files of time'

and

'For I doubt not through the *ages* one eternal purpose runs.'

One does not, however, make a mistake and supply '*one eternal*' after the '*ages*' in the first line, nor '*in the . . .*' after the '*ages*' in the second. The preceding words and the general purpose in quoting insure the recall of the right associates, whether strong or weak. The wider setting, the attitude or purpose, directs the course of recall.

Social Pressure as a Control of Association. — Of the other conditions of attention that were seen to determine the selection of sensations, education, social pressure, and heredity have their effect in controlling recall. Education both has a general influence in determining which associate shall present itself and also is responsible for bringing about the union of separate experiences to form groups which constitute the active forces in attitudes. An attitude, and in smaller degree a purpose, is very largely the result of the interaction of a large group of neurones united in earlier experience that serves to facilitate the recall of all of its members when one element is aroused. The action extends to further the entrance of the one among several associates that is most closely related to the group as a whole. One's attitudes grow out of, and are dependent upon, training and education. It is in preparing for these that education exercises its most important influence upon the selection of associates. Social pressure here, as in attention, is the most important element in enforcing duty. One is held to the disagreeable task by considerations of what others would think if the work be not finished, when it would be pleasanter to let the train of thought wander at will. A student

in writing an exercise wanders away for a moment in a day dream, but as soon as he is reminded of the task, the ideas connected with the writing reassert themselves. The course of association is held to the task until the work is completed. The considerations that enforce this return to the unpleasant course of thought are primarily social. It is probable that heredity has some influence in directing the course of thought. Thoughts of a certain kind are pleasant because of the natural endowment of the individual, just as certain objects are pleasant. In brief, the conditions that select one associate from the many possible ones are approximately the same as the conditions that select one from among the many possible stimuli that press upon the external senses.

The Nervous Basis of Attention. — In harmony with our preliminary statement that all mental action has a corresponding activity in the cortical cells, it is necessary to relate the conditions of attention to nervous processes. The nervous basis of attention is undoubtedly the selective preparation of certain cortical cells that makes excitation easy. This preparation is a state of partial activity that needs but to be increased by the stimulus to give full consciousness. In consequence a stimulus too weak to affect cells not thus prepared will arouse these to full activity. Each of the conditions discussed above may be traced to some preparation of this sort. The influence of the immediately preceding stimulus is to leave the cells it excites in a state of partial activity; they are still quivering from the earlier stimulation, and so respond easily to the new stimulus. The question or purpose arouses in some slight degree a whole group of connected cells. When a question is asked, the nervous impulse spreads from the cells excited

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by the question to others that have previously been excited in the same connection. An object appealing to any one of these cells will find entrance to consciousness made easy for it. Part of the work has already been done. The effect of education is, first, to connect the nerve-cells into large groups, and so to prepare for questions and purposes, and secondly, to make possible the spread of preparation from group to group, and thus to determine the course of the spread of preparation. It probably also makes certain paths permanently more permeable, and so more open to excitation than they were in advance of training. The hereditary bias has a similar explanation, except that the selective permeability is present in advance of training. Preliminary preparation in the nervous system is correlated with selection of sensations in consciousness, and each of the conditions of selection induces in the nervous system a state of partial activity which prepares for full activity.

The Neural Side of Selection in Recall. — The physiological explanation of the selection of ideas is very similar. In addition to the closeness of connection between the neurones directly involved that explains the objective conditions of recall, we have to deal with the action of other groups of neurones which either reinforce the action of one group or inhibit the action of others. If we present $\frac{6}{4}$ to a student three associates: 2, 10, and 24 tend to appear. The 2 has probably been most closely connected with the sensations offered. But if 'add' has been spoken by the investigator, the command will prepare the way for 10 and that will appear. The neurones stimulated by his voice added to the natural strength of the association will make the sum win against the difference. At any moment

the actual course of thought will be determined by the neurones which are also active or partially active, in addition to the one that stands in the direct line of association.

Interest and Non-voluntary Attention. — The conditions of attention can be reduced to certain peculiarities in the outside world and to different events in the life of the individual. But if one should ask the average non-scientific individual why he attends, he would answer in practically every case that he attended because he was interested or because he made an effort. If we examine our own consciousness, it is evident that attention from interest and attention from effort are natural divisions. It is desirable to refer this popular explanation and classification to the conditions already discussed. A list of the things that are interesting includes those that are attended to naturally and universally, such as stories of conflict. Attention to these we have seen to be due to heredity, to education, or to passing attitude or purpose. Some interests are general and innate, some are acquired by education, and some are temporary and seem to come and go without cause. To say that attention is due to interest is merely to say that it is due to some one of the subjective conditions other than social pressure. Attention from these conditions is pleasant and spontaneous. It has sometimes been called non-voluntary attention.

Effort and Voluntary Attention. — Attention due to effort falls almost universally under the socially conditioned. When one is said to strive to attend, the incentive is ordinarily some ideal of social origin. The real occasion for attending is the social approval that is expected or the blame that is feared if one fails to attend. The social incentive is generally given the name duty. This sort of atten-

tion is also marked off from the others by the accompanying diffuse contractions in different parts of the body that give sensations of strain. These constitute the feeling of effort. Attention induced by ideals of social origin and accompanied by effort is called voluntary attention.

Involuntary Attention. — Attention conditioned by the nature of the stimuli from the external world completes the list. This is called involuntary attention, since it may be opposed to the purpose and to the dominant ideals of the moment. It is always effortless, but may or may not be interesting. To exclude these stimuli is the usual object of effort. We may say that there are three sorts of attention: voluntary, non-voluntary, and involuntary. Voluntary ~~attention~~ is conditioned by social pressure and is accompanied by effort; non-voluntary attention is conditioned by the idea in mind, the mental attitude of the moment, education, or heredity, and is accompanied by interest; involuntary attention is objectively conditioned. It may be accompanied by interest if there is no conflict with the subjective conditions. If the external stimuli are opposed to the dominant purpose they may be resisted and so give rise to motor contractions and effort. In that case involuntary passes over to voluntary attention, provided purpose wins. The different forms cannot always be distinguished, but they serve the practical purposes of classification.

Adjustments of Sense-Organs in Attention. — Movements are among the most striking characteristics of the attentive consciousness. They serve as the only sign of attention to the onlooker, and are prominent in the experience of the individual attending. As one attends, the various sense-organs are adjusted to receive the impression

most effectively.) When one attends to an object in the field of vision, the eyes spontaneously turn toward it, the two eyes converge that it may be seen with the fovea in each eye, and the lens is adjusted to give the clearest possible image. The turning and converging of the eyes can be seen by the observer. One knows when talking to a person whether one is being looked at or whether the gaze is directed beyond, and infers from that the degree of attention one is receiving. This is the most common indication of the nature of the thing attended to. (Not only is there a characteristic position of the eyes for attention in the field of vision, but for hearing also and even for touch and taste.) Attention to objects perceived by the other senses is usually followed by visual attention to the same object. When one hears a sound, one turns the eyes toward it, and when touched, one looks to see what is against the skin. There are definite adjustments of the other senses to give the best condition for observation.

Motor Adjustments of the Body in Attention. — In addition to the adjustment of the sense-organs essential to perception, many more general muscular contractions accompany attending. One of the most important is the inhibition of all movement. When one is listening, all movements cease; even those that have started are stopped in mid course. Any sort of strong attention causes an unintentional cessation of activity. At the same time the breath is held momentarily, the heart beats faster, and other changes in circulation may be noticed. Quite as obvious and more important from the conscious side are numerous general contractions in voluntary muscles. In any attending the muscles everywhere are slightly tense. In marked degrees of voluntary attention the brow is wrinkled, the

/ i.e. con'd by social pressure + accompanied by effort.

voluntary & non-voluntary. 1st: preparation thro' some memory processes then stimulus.

muscles of the jaws are set, and the fists may be clenched. All of these are to the observer signs of attention, and at the same time they indicate to the man who attends that he is attending. The diffuse contractions give rise to the strain sensations which constitute the feeling of effort in voluntary attention. The motor processes serve to adjust the sense-organs to the most adequate reception of stimuli, — holding the breath and inhibiting general movements prevent the interference of distracting sensations, while the circulation is adjusted to the increased demands of the organism. On the other side they indicate to the observer that the man is attending, and to himself they give some idea of the degree of attention or at least of the amount of conflict in attention.

Is Attention or Movement Primary? — Much controversy has arisen in the last few years as to whether attention or movement is primary. One theory is that attention is due to the motor response; the other that attention is first and the response a mere accompaniment or result. The truth seems to lie between them. The essential fact in attention is the selective preparation. Movements of accommodation and clearness of conscious states are both results of this preparation. The preparation, as has been seen, is the outcome of the preceding activities of the individual, near and remote, and of the effects that these activities have had upon the nervous organism. The effect of this preparation as expressed in the attitude toward any stimulus is what we call attention. As seen by the individual, this is marked by selection of stimuli and by clearness of certain conscious states. As seen by another, attention is a series of movements, a visual fixation, a bodily attitude, or general strain. Of the effects of the preparation, we can

adjustment of sense organs to give greater definiteness of impression.

never be sure whether clearness or movement comes first. In many cases it can be observed that the stimulus presents itself in some vague way and the sense-organs gradually adjust themselves to give greater definiteness of impression. This is the usual order in involuntary attention. When the stimulus is expected, the sense-organs are prepared in advance. In that case preparation is usually determined by some memory process which precedes and initiates movement. This is true of voluntary and of certain forms of non-voluntary attention.

Attention Means Preparedness. — Attention, then, means neither the clearness of consciousness nor the movements that accompany the clearing up of a conscious state, but fundamentally the condition of preparedness of the individual and the organism that gives rise both to the change in consciousness and to the movements. This preparedness makes for selection, not merely of sensations, but of ideas and of movements. These have the same conditions and the same accompanying states of effort and interest. One is interested in mental states and actions as one is interested in objects, and one feels effort in holding to a train of thought or in selecting a course of action as in carrying out a difficult bit of reading or observation. The same characteristics that are prominent in attention are prominent in the selection of thought and action. The fundamental phase of attention is the preparedness that determines selection. It is the same in essence as the factors to be discussed later which control thinking and action. This, not any conscious change in sensation or movement, is what must be emphasized in attention. This preparedness is not, however, itself conscious. One does not know that one is likely to see one thing rather than

another until one sees it, and one does not know that certain movements of accommodation are coming until they are made. The only sign of the change that has been wrought by earlier activities is the effect in modifying selection and in inducing the accompanying actions.

The Duration of Attention. — Two practical questions arise with reference to attention. The first is how long any single stimulus may occupy the dominant place; the second, how many things may be attended to at once. To the question how long one may attend, various answers have been given. The ordinary opinion is that one may attend indefinitely. One seems to pay attention to the book one is reading for hours at a stretch, and one listens to a lecture for an hour with slight distraction. In all such cases, however, the material is constantly changing, one is not attending to the same stimulus, nor to the same sensation during the whole period. If one attends to any faint stimulus, the ticking of a watch or a faint gray ring on a revolving disk, it will be seen that one does not hear the sound nor see the ring all the time. It will be seen for a second or two, will vanish for four or five seconds, and then appear again. The total length of the cycles will be about six to ten seconds. These alternations are often called attention waves. More recently they have been referred to some periodical change in the sense-organ or in the nervous system, so are not to be regarded as changes in attention in the narrowest sense.

We must find some other answer to the question how long one may attend. While watching the faint ring to see when it comes and goes, one is aware of a constant shifting of attention. One drifts away from the ring to wonder whether one is attending or is attracted by some extrane-

ous matter or thing, and often the change in the sensation comes while thus distracted. A careful record that has been made of the maximum time that attention can be held to any single stimulus indicates that the pulsations are very short indeed. If one attempts to keep attention fixed upon a single point in a picture, it will be found that at least once a second something about the point will come in to crowd it out of consciousness. If the stimulus be absolutely simple and one is careful to record each appearance of something else, it seems that one can hold attention strictly to a single thing for less than a second. When in the popular sense attention is given to a thing for an hour at a time, attention is constantly shifting from part to part, or is turning to other objects or thoughts for longer or shorter periods. Attention for more than a second or so to absolutely the same stimulus is either impossible or results in the pathological condition of hypnotism.

The Range of Attention. — The question how many things may be attended to at once has also been variously answered at different periods in the history of psychology. The first statement, on purely a priori grounds, was that a unitary mind could have not more than one conscious process at one time. Later, experiments demonstrated that if a number of objects were shown for one-fifth of a second or less, four or five objects might be seen. More recently still, however, careful observation of the process of determining the number of objects shows that even with short exposures the objects are not attended to at once, but are impressed upon consciousness and persist for a time in the memory after-image, where they may be attended to separately and counted. It is as if one took an instantaneous photograph of a group of objects and counted them on the

film after development. The memory after-image persists only a second or two, however, and the number of objects that may be seen with a short exposure depends upon the number that can be attended to and counted before the image disappears. It seems probable from all the experiments that only a single object may be attended to at once.

Very much the same conclusion has been reached about the related problem of the number of things that may be done at once. Often two or more operations are apparently carried on at the same time. Careful investigation, however, shows that two things can be done simultaneously only if one has become so habitual as to require no attention. One may easily carry on a conversation while walking, but in this case walking has become so automatic that it requires no conscious guidance. Should the way become very rough, conversation will cease or will suffer long and frequent interruptions. Experiments have been made to show that one can read a selection and add a series of figures at the same time more quickly than one could do both in succession, but if either task is difficult enough to require full attention, the two will take more time when carried on together than when done successively. When easy and familiar, one task will be carried on automatically while attention is given to the other, but when both require full attention, only one can be continued at a time to advantage.

Note

Note

Attention and Inattention. — A natural question arises as to what the opposite of attention may be, or whether there is ever a time when one does not attend. Complete inattention is noticed only during sleep or periods of unconsciousness. Even in sleep there is apparently some selective adaptation to stimuli. A sleeping man will be aroused by his name even if spoken in a tone so low that he has

heard nothing else of the conversation. In profound slumber a mother is 'set' for the movements of her child, the nurse for the patient. In the insane, too, attention is present although in a reduced or distorted form. The so-called states of inattention of the normal man are really states of attention, but of attention to something at the moment undesired. They divide into two forms, — scattered or diffuse attention, and absent-mindedness. In the one, attention is constantly shifting to a new object, and no one is kept before consciousness long enough to be fully appreciated. In the other, attention is so absorbed in some one thing or course of thought that other sensations have little chance to enter. The first form is more frequent in childhood and in certain pathological states, such as mania, the other is more usual in maturity and is frequently found in men of more than usual training and ability. Both forms of inattention are desirable if not in excess; in fact they are extremes of the two desirable characteristics of attention. Attention is most effective when all useful objects are attended to, and attention is kept upon them long enough to appreciate them fully. Dispersed attention insures entrance of all important objects, the abstracted state protects against distraction that might prevent full understanding. It is only excessive instability or too great and inappropriate immersion in anything that should be guarded against.

Attention and Distraction. — It is generally thought that any distraction, any stimulus that may present itself at the time one is endeavouring to attend to anything else, will diminish the amount of attention and so render observation less accurate. Experiments show that this is not always true. If one is comparing two intensities, *e.g.* first undis-

turbed and again when a phonograph is playing near by, it is found that at times the judgment made during the distraction may be more accurate. Certain individuals and all individuals under certain conditions seem to do better work when the room is not too quiet. Much depends upon the strength of the distraction and the health and attitude of the individual. Acts that require a very short time are less affected than those that occupy more time.

Recent experiments by Dr. Morgan and later by Dr. Ford offer a suggestion that may explain the apparent contradiction. Dr. Morgan asked a student to press a certain key when one of a number of colours appeared upon a disk and to press another key when another colour appeared, etc. Other complications were introduced which demanded very close attention. The quickness of mental processes was measured by the time required to make the response. Simultaneous records were taken of the pressure exerted upon the key, and of the depth of breathing. The task was performed first without, then with, distraction. In most subjects the distraction at first caused a decrease in the quickness and accuracy of work, but this soon changed to an increase in effectiveness. Study of the records of breathing and of the pressure exerted upon the key showed that while the distraction acted, the key was pressed harder, the breathing was deeper, and that slight vocal movements were used to aid in thinking of the movement to be made. The apparent explanation of the effect of distraction in the light of the results is that the individual exerts himself to overcome the distraction and puts forth more than enough extra effort to overcome it and in consequence does more than before, but at the expense of extra fatigue.

The Genesis of Attention. — Attention must be present

in the child in some form from the very earliest months; the change with years is primarily in the conditions that control selection and the constancy with which attention is kept upon one object. At first, selection must be controlled by the external stimuli and heredity. The infant is attracted by intense stimuli of any sort and by moving objects. Very early, experience shows its effect and the child begins to notice, in the chaos of the new and unfamiliar, objects that have been seen frequently. From this time on, each experience prepares the way for a new experience. The effect of these experiences is determined by the closeness of the relation of the experience to inherited tendencies. When they oppose heredity the effect is slighter than when they aid it. At this stage the development of interests begins. These are to grow with all learning and all experience and must change and develop with each new bit of knowledge. With the school years or earlier comes the appreciation of duty and other rudimentary social demands. At this stage the child makes a beginning in keeping attention fixed upon the more unpleasant thing which is approved by society in the face of the more pleasant. Training in attention of this sort comes at first through seeing the advantages of attending in harmony with social ideals as enforced through discipline. Later, obedience to the calls of duty becomes more or less habitual and the habit constantly grows and changes through application in new fields. In terms of our classification, attention begins with the involuntary and the hereditary sort of non-voluntary attention; soon the other non-voluntary forms develop; and last of all the voluntary.

Summary. — Selection is an omnipresent phase of conscious life and profoundly affects behaviour. It is possible

to select sensations, memories, and actions. The conditions that lead to the selection are the same in each case. They are to be found in the intensity of the stimuli, the strength of the memory or the habit on the one side, and in the momentary attitude, education and heredity, and social pressure on the other. Selection in any one of these fields is accompanied by interest if conditioned by education or heredity, and is accompanied by diffuse strain sensations that give rise to the feeling of effort if the selection is controlled by duty. The act of selection is called attention when applied to sensations; it is called voluntary control of ideas when applied to recall; and is called will when applied to action. So far we have considered explicitly only the control of sensations and memories, although what has been said here of conditions and accompaniments holds of the other processes as well, as will be made clear in due time. It should be emphasized that the terms used to describe the fact are less important than the fact. The fact of selection is called will in many of its applications, as it has been called attention in this chapter. There should be no quarrel as to whether will or attention is the more important, as each is but a word used to designate different applications of this fundamental phenomenon with its conditions and accompaniments. The fact is essential, the name is a matter of usage. We shall make use of the fact in connection with all mental operations.

n.b.

QUESTIONS

1. Give an instance of the way sensations are selected. Do the sensations that are not selected enter consciousness? If so, how do they differ from those which are selected?

2. What is the motive for attending to a musical selection? To

solving these problems? To a loud noise? Why do you notice your own name whenever it is seen on a page? Trace the acts of attention to the conditions mentioned in the text.

3. Cite instances of attention that are due to each of the subjective conditions.

4. Are the movements which accompany an act of attention its cause or its effect? Give evidence in favor of your opinion.

5. Is interest cause or effect of attention? What is interest? In what sense is it a condition, in what sense a mental state?

6. Answer the same questions for effort.

7. Outline the changes in the nervous system that explain selection. Are they the same for all conditions?

8. Is distraction ever favorable to mental work?

EXERCISES

1. Paste five bits of paper of different shapes and colours and four letters upon a square of cardboard. Show it to a group with the request to tell what colours they see. Note the answers. After an interval of half an hour ask what the shapes of the coloured papers were; then what letters were seen. Compare the percentages of objects seen that corresponded to the questions with those which did not.

2. Look closely at a point on an evenly illuminated and coloured wall. Can you distinguish any difference in the intensity or brightness of the point looked at as compared with the surrounding areas? Have an assistant strike several notes upon some instrument. Attend first to one then to another. Does the attending increase the apparent intensity of the tone or merely increase its clearness?

3. Recall as definitely as you can some act of attention that involved effort. Can you analyze the components of the feeling of effort? Lift a heavy weight that also requires effort. Is the quality the same as in the effort of attention? Can you trace the feeling to any sense-organ?

4. Watch a small dot so far away that it can just be seen. Can you see it all the time? How many times a minute does it come and go?

5. Try to keep attention upon a dot when near enough to be seen

easily. Can you watch it all the time? Keep a list of the memories or other sensations that come in to crowd it out. How many times will attention wander from it and come back to it in ten seconds?

6. Have an assistant prepare a set of cards with different numbers of dots upon them. Let him place the cards face down upon a table and show them one after another for an instant by turning them over and back. What is the largest number of dots that may be seen at a single glance? Do you count them during the exposure or from memory later?

7. Try counting from 20 downward and at the same time write the digits from 1 up to 20. Take the time. Take the time required for each separately. Compare. Introspect to explain the difference in time required.

8. Add a column of two-place figures while the room is quiet and all is favourable. Add a second column of the same difficulty while an electric bell is ringing continuously. Add while two people are having a conversation near you. Compare times and errors under the three conditions.

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CHAPTER VIII

PERCEPTION

NB

Perception Involves Interpretation. — As we turn from the formulation of the general laws that must serve in the explanation of all concrete mental operation, we have only to see how these simple laws are applied. We may begin with perception, the becoming aware of objects in the world without. At first it seems as if there were no problem here. Most of us have the notion that our senses are in immediate contact with the physical world and so mirror its objects as they are. A little observation and reflection shows that the original sense impression is worked over in various ways before what we call the simple object develops. In Chapter III, it was shown that the nature of the sensation itself depended more upon the nature of the sense-organ and the cortical centers than upon the physical stimulus. This sensation is greatly elaborated before it is finally accepted as knowledge. When, for example, we see the disk of the full moon, the circle of stimulated rods and cones serves as little more than the occasion for the development of the complete idea. We change the size we assign to it according to its height in the heavens; it appears much smaller at the zenith than on the horizon. When it is looked at out of the side of the eye, we see it as a complete circle, although the actual area stimulated on the retina is an ellipse. We read into the dark spots on its surface ideas of mountains and volcanoes that have been derived from descrip-

tions and theories of astronomers. The sense stimulus serves as little more than an incentive to the arousal of the total percept. The study of perception is a study of the way in which the construction takes place.

Perceptions Involve Recalled Elements. — The sensory elements first suggest memories. These take two different types. Separate sensations rearouse single memory images or centrally aroused sensations. These combine into the mosaic that we call technically the percept and accept, popularly, as the object. In our uncritical daily life we do not ordinarily distinguish the sensory from the recalled components. In feeling a rough surface in the dark, one recalls how surfaces appear that have given similar tactual sensations. If the arm is moved with the eyes closed, one ordinarily pictures from memory the different positions of the arms; one does not feel the sensations from the arm that tell of the motion. Similarly, in any perception, the object is made up in part of memories and in part of sensations. In perception through any sense the same law holds. When a dog barks at a distance, the dog is pictured in its proper direction, — visual memories are added to the auditory sensations. The memory additions can be actually discriminated under certain conditions. In Figure 26, taken from Jastrow, the shadows alone are drawn but one seems to see the solid letters that would cast the shadows. They are a little faint, but are unmistakable and can be seen even under conditions most favourable for observa-

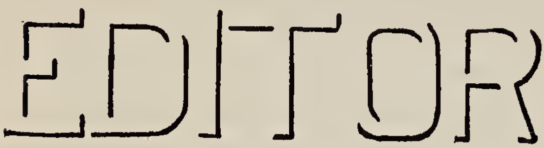

Fig. 26. — (From Jastrow, *Fact and Fable in Psychology.*)

tion. In most perceptions there are similar additions from memory, although they are not always so easily distinguished.

Perception of Objects as Real. — In a greater number of cases we do not add single memory elements to single sensations, but the stimulus suggests an object ready made in past experience which is aroused as a whole. This again raises two questions. The first asks how the notion of the object was developed, the second what leads to the selection of one rather than another from the store of objects. It might be assumed that percepts were developed by the selection of the impression that arises under the most favourable conditions. Thus one would accept as true the image of the moon that is seen when the center of the disk falls upon the fovea in each eye, and would disregard the image that is seen out of the side of the eye. The one seen under the most favourable conditions would be substituted for those seen under the less favorable conditions.

No Mere Mass of Sensations Is Accepted as True. — This, however, is not alone sufficient, for even the most favourable conditions of observation never give a picture that will be perfect in all detail. Thus, no single present image can give the top of a table as we know it to be and as we seem to see it in casual observation. When seen from the side it slants in one direction. When seen from in front the sides converge towards the back. Even if looked at from a point directly above the center, the sides would not be straight. This we know from the fact that the retina is a sphere and so lines projected upon it must be curved. We can prove this by direct experiment. In Figure 27, taken from Helmholtz, if you will look at the center when it is held only an inch or so from the eye, all

the lines appear straight and the angles, right angles. The figure is drawn in such a way that the curvatures are just corrected by the change in the image that produces a distortion of straight lines as they are normally seen. Every-

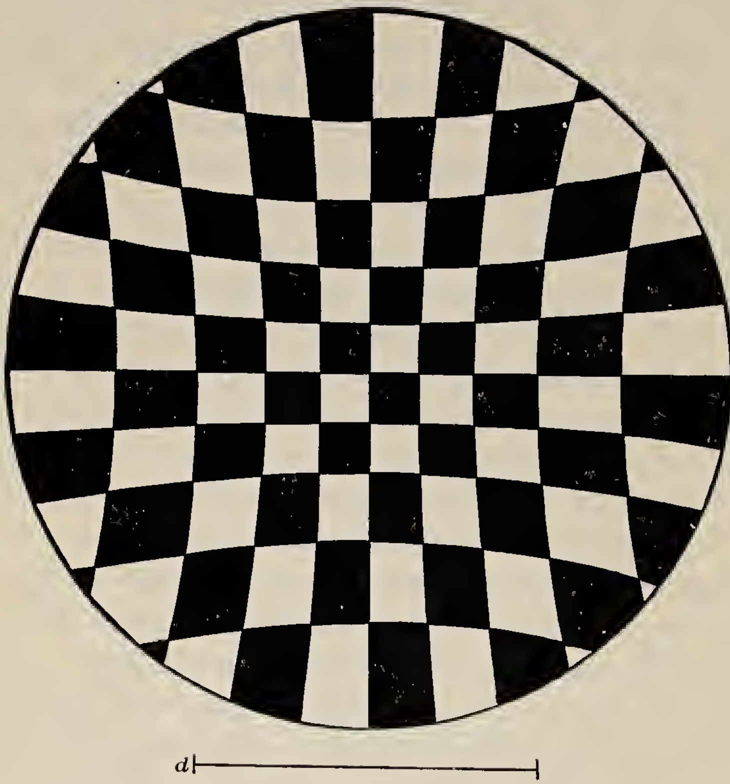

Fig. 27. — To show the distortion in the periphery of the visual field. Hold the center of the figure at a distance from the pupil equal to the line below and the lines are all straight and the angles right angles. (From Helmholtz.)

thing we see on the periphery of the retina is distorted in the direction opposed to this. While the retinal image must always have been distorted in some way, the object as we perceive it is rectangular and the edges are perfectly straight. Obviously factors other than the recall of a single

earlier memory must have been effective in making the sides straight and the angles right angles.

Perception a Process of Trial and Error. — The most important factor in the development of a true notion of an object is the repeated series of tests that must be made of it. Some of these are actual tests in action. One moves the table and finds that it will fit into corners that are known by measurement to be square. To make it fit, the table must have square ends and sides. In other cases the trials are in thought rather than in action. One casts about for a construction that will harmonize the different single views or groups of sensations and when one is found which is consistent with all, it is accepted as true. This casting about is often not specific and intentional, but arises automatically. The store of percepts or notions of objects that we have available has been developed by these two types of trial. By constant trial and use, a construction develops that proves true when tested in any way. This is accepted as the real object as opposed to mere sensations. All the uses and tests that have been made harmonize with the assumption that the table top is a square, and as a result of all of these experiences one sees it square, whatever the retinal image may be. The results of all of the various experiences coöperate in giving the object that is seen the appearance it has. To put it the other way, the object that is seen is the one that serves to explain the different earlier experiences; it is the one that harmonizes all of the uses and observations we have made of it in the past. Whenever the appropriate sensation presents itself, this developed object arises in consciousness.

Sensations Which Do Not Harmonize with the Whole Are Suppressed. — Not only do constructions developed

in the past by frequent tests supplement and even replace the actual sensations which present themselves, but sensations shown by test not to correspond to real objects are overlooked or suppressed altogether. Probably many readers of this book never saw an after-image until they read the chapter on sensation, although every visual sensation has its after-image. Again, ordinarily you do not see the shadows cast on the rods and cones by the retinal blood-vessels, but if in the dark a candle be held a little to one side of the line of vision and moved about, the network of vessels will be evident. These shadows are overlooked because they have no meaning in the world without. In general, perception is always of real objects; sensations that do not correspond to real objects are always neglected. The character of the percept is changed to correspond to what has proved to be the real object. An object in its turn is real if it will stand the ordinary tests, will satisfy the different uses to which it may be put, and will harmonize with all the related experiences. What one sees is the object which has proved itself real as a result of the earlier perceptions and which stands the test of all the trials.

Perception Dependent upon Earlier Knowledge. — If perception is in large part a process of arousing earlier developed notions of objects, it is obvious that the presence of a store of suitable knowledge is essential to adequate perception. This is further proved by the failure to understand or even to hear all that is said in a foreign tongue. One could not repeat accurately even a short sentence in French if entirely unfamiliar with the language, and this largely because the sounds would not be correctly supplemented. One sees much more in an instrument that one already knows something about. To go back to the begin-

1. horizontal molded projection crowning a building.

ning, it is probable that the child sees practically nothing in the world because it has nothing to bring to it in the way of earlier experiences.) As he accumulates images or notions of specific objects, he is able to bring them out on the occasion of a particular sensation. (They serve to interpret the stimulus and constitute a large part of the object perceived.)

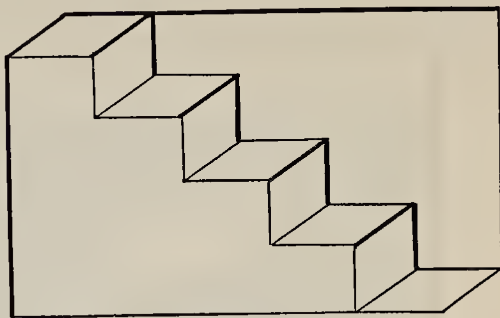

FIG. 28.

The Determinants of Perception. — Finally there is the problem here, as in recall in general, of selecting the idea most appropriate to the present occasion from among the older memory elements and organized memories that may be available. Recall is determined here by the laws of association discussed in the last chapter. Both the simpler physiological strength of connection and the more subjective conditions are effective in determining the arousal either of the simpler centrally aroused additions or of the more fully developed notions. The influence of mental attitude in selecting the interpretation to be given can be readily illustrated. The drawing in Figure 28 may be seen, either as a flight of steps or as a 'cornice, according as one brings the right ideas to bear. The figure from Jastrow, Figure 29, may be seen as a rabbit's head or as a duck's according as one thinks of one or the other. The same dependence upon attitude may be seen in more usual perceptions. If one is listening for some one approaching at night, many sounds are likely to be interpreted as footsteps.

In short a percept is not a mere mass of sensations but a mental reaction to a situation. This reaction is aroused (1) by a sensory stimulus or group of stimuli; (2) it consists in part of motor responses; (3) in larger part it is due to the addition of memory processes to the original sensations; (4) the memory additions are in most cases already

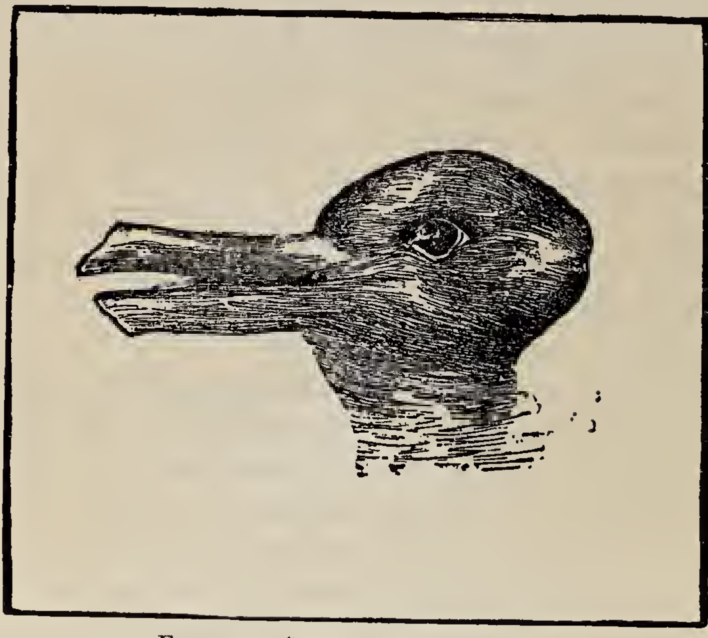

FIG. 29.—(From Jastrow, *op. cit.*)

organized notions of objects developed through bodily reactions and mental interpretations of similar situations in past experience; (5) the interpretation which is added is determined by the laws of association controlled by the mental attitude and the more general influences discussed under attention. Since the percept satisfies the different uses to which it may be put and the conditions of the moment, it is accepted as real, while the actual sensations may be rejected as unreal or illusory. We may proceed to

see how these general principles are illustrated in the different forms of perception ordinarily recognized.

Perception as Gestalt. — Mention may be made of a different interpretation of this phenomenon by the recent 'Gestalt' school. They recognize much the same facts true that we have, but emphasize a different attitude towards them. They, too, believe that an essential part of every

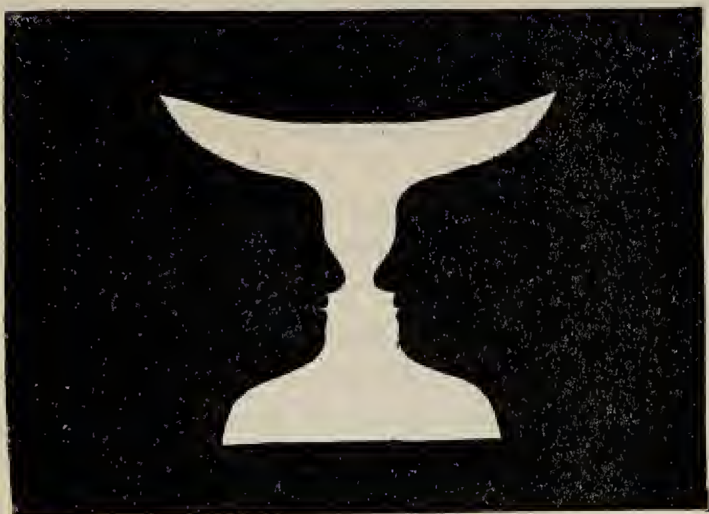

FIG. 30. — Shows the alternating application of two Gestalten. (From Wheeler, *Science of Psychology*, after Rubin, by permission of Thomas Y. Crowell Company, publishers.)

perception is adding an elaboration to the stimulus. They assert, however, that this addition is ~~not~~ derived from experience, and cannot be analyzed into elements, but is to be regarded as part of the endowment of the individual who sees. It is unitary and unanalyzable and so must be untrue taken for itself and not be investigated farther. The process is represented in Figure 30 taken from Rubin. If you look as you are likely to with the white as the figure and the black the background, you see a goblet with an

ornamental stem. Look at the stem more closely, the white becomes the background and the black the figure, and you see two men with symmetrical faces looking at each other. On the Gestalt view, the two interpretations are unitary wholes which are available to the observer and are applied one after the other. As opposed to the theory we have presented, that is all that can be said. No analysis is attempted and no reason is given why one should appear rather than the other. The theory assumes that all mental life is given in these unitary wholes and that any mental operation consists in the becoming prominent of one or another 'Gestalt,' or figure.

The Perception of Space. — Two properties or attributes of experience are sufficiently alike for all objects to be given a general treatment. These are space and time. Space has been particularly thoroughly investigated. Following the usage of geometry, psychology distinguishes three phases of the perception of space: (1) the perception of position, (2) the perception of distance on the surface of the sense-organ, and (3) perception of depth or distance away from the sense-organ. Each of these illustrates the general laws of perception. The perception of position on skin or eye is so simple and has been made so frequently that it is difficult to distinguish, directly or indirectly, the immediate conditions that give rise to it. If one is touched upon a finger or the cheek, one knows at once what the point is that has been touched, but one cannot say how it is known that it is that point and no other. That the perception of position involves physiological and psychological processes is evident from the fact that the accuracy of localization varies from point to point on the body. This may be demonstrated by two experiments. Have yourself

touched on the skin and try to indicate the point. You will make a mistake of a millimeter or more if the point be on the finger tip and of several centimeters if on the back or thigh. Or you may have some one touch you with two compass points and determine how far apart they must be before you can say that they are two rather than one. This distance is the 'limen of twoness.' On the finger tip it is about 1 mm., on the back, 40–60 mm. Similarly for the retina, one finds a 'limen of twoness' at the fovea of .002–.006 mm. or about the distance between the cones. The limen increases very rapidly with the distance from the fovea.

The 'Local Sign.' — To bring these facts under our explanation of perception, it is necessary to find, first, some old experiences that were suggested when the point was touched, and second, the peculiar quality of the point that suggests them. Various theories have been held concerning the nature of both. (1) One of the oldest is that there is a sign of position, the 'local sign,' which is different for each point touched and for each point of the retina stimulated, and that this 'local sign' suggests the position. No one has accurately described the 'local sign,' however, and one cannot discover it when one seeks it. (2) Another theory is that stimulation of each point on the skin tends to call out some reflex movement and that this reflex is different for each point. There is, on this theory, either a movement or a tendency to movement which is different for each point of the skin or eye. This theory is partly satisfactory; the main objection is that one can recognize position more accurately than one can touch points on the skin, and that the eye is constantly moving over distances greater than the least appreciable differences in position. (3) The sug-

gestion is made that stimulation of a point on the skin recalls a visual picture of the place touched. This is the only suggestion that can be confirmed by actual observation.

Position a Notion Developed by Trial and Error. — The most that can be said is that perception of position is due to some peculiar quality or motor connection attaching to each point on the skin or retina. It is likely that 'position' itself is an idea so frequently used that its nature has become very complex, and the elements are no longer analyzed from the mass. It is made up partly of movements or tendencies to movement and partly of ideas derived from sight or touch as the case may be, but it also involves a number of other elements. This notion of position, whatever its nature, explains all the various experiences and responds satisfactorily to all tests. With use, the completed notion has come to replace the different elements so entirely that they are lost in it, and cannot now be analyzed from it. The stimulation of any point on skin or retina calls out the corresponding notion of position, and that is all that can be said with certainty.

Perception of Distance. — The perception of extent on the surface of skin or retina may in part be analyzed into similar elements. (1) Movement, either of the organ itself or of the hand over a surface is an important factor in perceiving the distance between two points. Several illusions indicate that one appreciates extent on the retina by moving the eyes from point to point. Thus, vertical distances are overestimated as compared with horizontal distances, because the adjustment of the eye muscles makes vertical movements of the eyes more difficult than horizontal ones. Distances on the skin also tend to be translated into move-

ment, and the mistakes made show dependence upon movement. (2) In addition, it is probable that extents on the skin are translated into visual distance for interpretation, and the visual distances may more rarely be translated into distances on the skin. That there is usually reference from one sense to another is shown by the fact that where two systems of extent are independent and not corrected by comparison, large mistakes are apt to be made. This explains the large size that cavities in the teeth seem to have when felt by the tongue, as compared with their size when seen in the dentist's mirror. (Space as perceived by the tongue is seldom corrected by visual space, while other tactual distances are constantly subject to that correction.) Distance, then, like position, is a general notion developed from numerous experiences and accepted as true because it works. This notion is aroused whenever one estimates distance by the eye, on the skin, or by movement of the members. What it is in itself one can no longer say, if one ever was able to analyze all of the experiences that have gone to make it up or that have served to develop it.

Perception of the Third Dimension. — The perception of the distance of objects from the eye illustrates all of the laws of perception even more clearly than the simpler forms of space perception. The striking fact in connection with perception of this third dimension is that, while the rays of light affect the retina only, the source of light seems to be some distance away from the eye. Evidently distance cannot depend upon how the retina is stimulated, because a point of light affects the retina in the same way, whether it come from two feet away or from a fixed star. That the actual distance makes little or no difference can also be demonstrated by the fact that objects within the eye and

This is perception of depth or distance away from the sense organ.

even within the retina, when seen at all, seem to be in the outer world, and at a distance from the eye that depends upon the adjustment of the eyes at the time. So, if one lie upon the back on a summer day gazing upward, one will notice little bright specks rushing over the sky. These are the blood corpuscles darting through the blood-vessels in the retina, but when the eye is fixed upon the sky they appear to be far away. The problem of the perception of distance is one of determining what characteristic of the excitation calls out the idea of distance, and what the nature of that idea may be.

The Physiological Factors. — The factors which serve to suggest the distance have been pretty fully made out. They may be classified into eight groups, three physiological and five psychological. The physiological factors are related directly to the adjustment of the eyes. 1. With one eye only, the most important element is the change in the contraction of the ciliary muscle that focuses the eye for different distances. If one looks at a distant object, the muscle of accommodation is relaxed and so the lens is held flat; when one looks at a nearer object, the muscle contracts and permits the lens to become more round. One may feel the change in strain as one looks from a remote to a near object. This strain of accommodation gives an idea of the distance of the object. Slight strain means distance, increased strain means nearness. The estimation of distance by one eye is much less accurate than with two eyes, as can be shown by asking one to put his finger through a ring held sidewise. With one eye closed large mistakes will be made, while with two eyes one can put the finger through each time.

2. Muscular strain is also a factor in binocular perception

of distance. When one looks at a distant object, the eyes are parallel; as one looks at nearer objects, the eyes converge, and the nearer the object, the greater the convergence. This can be seen directly in another's eyes. When he looks at a distant object, the white shows about equally on each side; as he looks at an object only a foot away, considerably more white will show on the outside than on the inside of the eyes. This adjustment is made known to the observer by the strain sensations from the muscles which turn the eyes. These vary with the distance of the object. The nearer the object the greater the strain in the internal recti muscles. It is to be emphasized that none of these strain sensations are noticed for themselves. They are overlooked in the general interpretation, and one appreciates the distance alone, not the strains that suggest it. Note.

Double Images. — 3. One of the most important elements in the perception of distance is the different appearance of an object as seen by each eye. If one will hold any object before the eyes and look at it first with one eye, then with the other, it will be noticed that one eye sees more of one side, the other more of the other. When both are open, one may even distinguish in the common view of an object the contributions of each eye. When an object is small and not converged upon, the doubleness of its image can easily be noticed. Hold two pencils at different distances in a line directly away from the eye and it will be seen that the one not fixated is double whether it be the nearer or the farther. The greater the distance between the pencils and the nearer they both are to the eyes, the more separated are the double images. As a result of experience we have developed the tendency to estimate the distance of all objects from the degree of difference offered by the pictures

to the two eyes or by the degree of doubleness of their images. The greater the difference the greater the distance we assume to exist between them. The doubleness becomes an immediate sign of the distance of the object. It is the

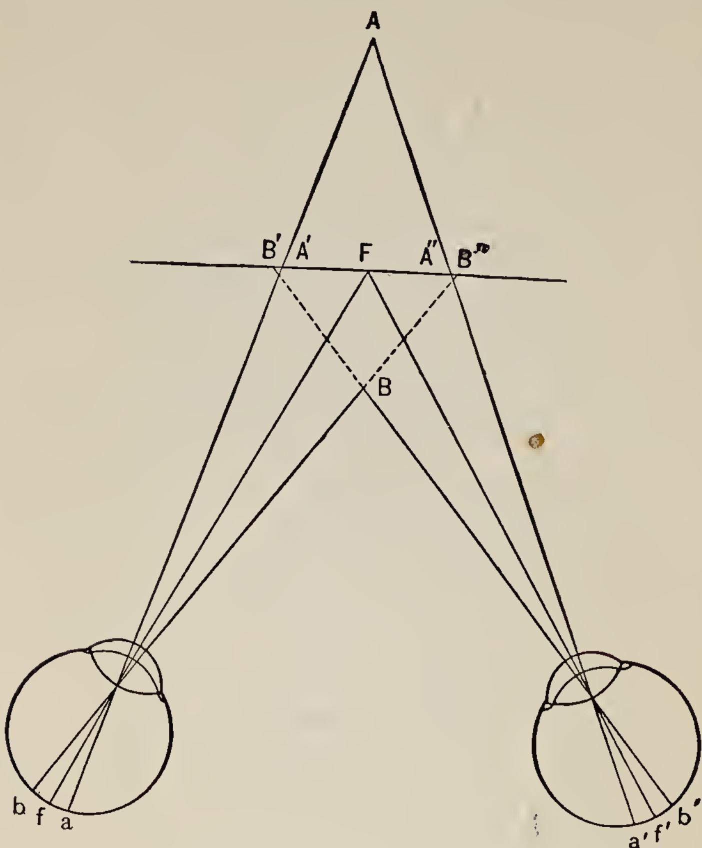

Fig. 31.—To illustrate the perception of depth through double images. (F) is the fixation point, (A) and (B) farther and nearer points. Both nearer and farther points are projected upon the plane through the fixation point to which all are referred and so are seen as if double; (B) as if it were at both B′ and B″; (A) as if it were at both A′ and A″. The small letters indicate where the points (A), (F), and (B) actually fall upon the two retinas; (b), (f), and (a) in the left eye, and (a′), (f′), and (b′) in the right eye.

interpretation we place upon these double images that gives the apparent depth to the field of vision.

The Stereoscope and Double Images. — These double images give the appearance of depth even when there is no depth present. This is clearly seen in the stereoscope. The stereoscope slide has two photographs taken from slightly different positions. When the two pictures are combined, the result is a series of double images similar to those that would have been produced had the observer been standing where the photographs were taken. The differences in the pictures may be seen if one will compare the position of the same object in each. An object in the foreground will be seen nearer the right edge of the view in the left picture, and farther from it in the right picture; in the background, the relation is reversed. These double images again are not noticed for themselves, either in perceiving actual distances or in the stereoscope. They are overlooked in favour of the distances they suggest.

Psychological Factors in Depth Perception. — The psychological signs of distance are found in certain qualities of images which vary with the distance of their objects. (1) The most important of these is the variation in size of the retinal image of objects as they change their distance. This is the element which the artist makes use of in perspective drawing. He draws the more distant objects smaller than the nearer, and we interpret that to mean that they are far away. (2) A second sign of distance is the haze and changed colour that come with distance. Distant objects are hazy, indistinct, and blue in colour, while near objects are clear and have their own colours. The changed colour and haze depend upon the amount of air intervening. In a very clear, dry air, estimates of distance are subject to

large mistakes on the part of one who comes from a lower altitude and denser atmosphere. Far away objects show but little haze or change of colour, and in consequence are regarded as much nearer than they actually are. (3) A third factor of some importance is the rate of movement, of the object itself, if it moves, or its apparent motion when the head or body of the observer is moved. If the usual rate of motion of an object is known, its apparent rate indicates its distance. Far objects seem to move more slowly, near ones more rapidly. A distant railway train seems to crawl across the landscape, while the near one rushes past. As one moves the head with the eyes fixed upon the horizon, near objects are displaced considerably, distant ones very slightly or not at all. If one is looking at a near object and moves the head, objects far from the point of fixation move more, those near it less. One may estimate the distance of the object from the apparent rate of motion. (4) A fourth very simple sign of relative distance is superposition. Objects that hide parts of other objects are evidently nearer than the objects covered. (5) Finally, shadows furnish a means of estimating the relative distance of parts of the same object. Bright parts of the surface are ordinarily nearer, shaded parts more distant. The interpretation depends largely upon the way the light is falling, but with any illumination, lights and shadows give a means of estimating the relative distance of the parts. These five characteristics of the retinal image combine with the three factors mentioned above to produce our notion of the distance of seen objects. The idea of distance depends upon all taken together.

Theories of Depth Perception. — If the suggestion for the distance is found in one or more of these factors, the

question at once arises what the idea of distance is in itself. One of the early theories and one that still has many advocates is that the various signs of distance serve to recall memories of earlier movements which were necessary to reach the object. Movement, no doubt, contributes a large share to the general idea. It is certain also that other elements enter. Estimates in terms of movement alone are more inaccurate than those in terms of vision alone. We have, for example, no accurate idea of the distance walked through in the dark, and walking in the dark, one frequently tries to think how great the distance would look. Certainly the visual estimate of a distance is ordinarily more accurate than the purely motor estimate. It is probable that the idea of distance is complex, made up of a great many particular experiences. In this, it is like the idea of position or of extent on the surface of the sense-organ. What elements have contributed to the total effect cannot now be determined accurately. But to movement must be added the appearance of the distances, when viewed from the side and from other angles, and all the various activities that are furthered and hindered by distance. Whatever this complex idea may be, it is at once suggested by the strain sensations, by double images, and the various characteristics of the image which constitute the psychological signs of depth. Each of these primary space ideas has special stimuli that suggest it, and is itself a complex idea that is like no single experience, but is derived from and explains many experiences. Space, as a whole, is only another general idea of the same kind and origin that unites and explains the several less general spatial ideas and which is related to each of them, or combined from them.

Perception of Motion. — A second form of perception related to the perception of space and common to all objects is the perception of motion, particularly perception of motion by the eye. We may distinguish two ways of recognizing motion. In one, we actually see the object move; in the other we merely infer that it has moved because it changes its position between observations. The first is illustrated by the second hand, the other by the minute hand of a watch. The former alone requires explanation. One view is that the immediate sign of motion is the after image left on the retina by the moving object. If the hand is moved across the field of vision, it will be noticed that a streak is left behind it which persists for a brief time. One will also seem to see a movement if the same object is shown successively at positions not too far apart. If one line is shown and then another a little distance above it after an interval of .06 seconds, the first seems to have moved to the position of the second. In that case many observers report that there seems to be a streak of black extending from one to the other. On the assumption that one interprets motion on the basis of the after-image, it would mean that one adds the usual accompaniment, the streak of black ordinarily given by the trail of after-images, even when there was no after-image possible. The first interpretation is movement, but that recalls the streak, the most usual sign of motion, as soon as the interpretation was made.

The Motion of the Movies. — The illusion of motion in the moving picture depends upon this principle. The successive appearance of the same object in different places is immediately interpreted as the motion of the object from one place to the other. These successive exposures may give the trail of after-images directly, a trail in which the

gaps between exposures are not noticed. The trail is also supplied subjectively by association. It should be added that the after-image, both in actual motion and in the pictures, is only the intermediary for the more general notion of motion that develops, much as the idea of space develops, to coördinate and explain the various experiences. This meaning or interpretation is more important than the trail of after-images, although the latter has become closely connected with it in the observation of most people. Wertheimer introduced the 'Gestalt' theory with the statement that whether one saw motion or not depended upon the entire setting, and could not be referred to any one phase of the object or position.

As in perception everywhere, the mental attitude and the external situation aid in deciding whether there should seem to be motion and which object should seem to move, as between motion of the eye and of the object or when motion may be ascribed to one of several objects. Where both eye and object are in motion, the motion of each must be inferred from the various after effects. The interpretation in each case is not explicit. As in most perceptions, the result alone is evident; the occasion for the perception is overlooked. In many cases movement is ascribed to one object or another on the basis of probability. In this a mistake is often made. For example, when one is sitting in a car in a station and a train on the next track starts, one is very likely to believe that one's own car has started. This is because one expects the car to start, and also because one is not accustomed to seeing objects move which are as large as the side of the car. The retinal image is ambiguous, and motion is ascribed to the object which seems most likely to move.

The Perception of Space by the Ears. — Two problems must be considered in relation to the auditory perception of space, the appreciation of the distance from which the sound comes, and its direction. In both cases the reference is to sight. When one hears a sound, one at once gives it a place in the visual field. The problem in each case is to determine the characteristics of the sound that suggest one distance or one direction rather than another. The distance to which a sound is referred depends very largely upon the intensity of the sound, provided the actual intensity is known. The barking of a dog is appreciated as near or far according to its loudness, as compared with the remembered intensity of the sound when the dog is barking near at hand. Allowance is made for the bark of different kinds of dogs on the basis of the quality of the bark. Where the nature of a sound is misinterpreted, the distance is wrongly estimated. The buzzing of a fly very near is occasionally mistaken for some strange, loud noise at a distance, and similar mistakes in judging distances are rather frequent.

The direction of the sound seems to be appreciated by the difference in the intensity or quality of a sound as it affects the two ears. A sound to the right affects the right ear more strongly, a sound to the left stimulates the left more intensely. The tone will also be in a different phase in one ear from what it is in the other. (The relative differences serve to indicate the direction of the sound.) In the median plane, the plane midway between the two ears, the effect upon both ears is the same, and in consequence in this plane it is very difficult to say where a tone is. A pure tone directly in front may be referred to a point directly behind, or to any other part of this plane. Young has recently succeeded in reversing the direction of sounds, by

a device which leads a tube from an ear trumpet in front of one ear into the other ear. This makes the fainter tone come to the ear on the same side of the head as the object, the stronger tone is carried to the ear turned away from the source of sound. The tone seems to come from the side opposite to that from which it actually comes. While the different intensities of the tone as it presents itself to the two ears seem to be the important element in the determination of the direction of the pure tones, noises and complex tones apparently undergo some slight change in their quality with change in direction, which indicates position. This change in quality is due to factors that have not been altogether determined, but it seems probable that it is in part the result of the reënforcement of different components of the complex as the sound comes to the ear from different directions.

The Space of the Blind. — For the blind, the auditory perception of space is much more important than for the seeing individual. Not only are they more accurate in all of their localizations of sound, but they use sound to obtain an idea of the space in which they are walking, and of the distance of obstacles. The echo of the footsteps varies with the size and shape of the room, and the time between the echo and the original sound increases with the distance of a wall or other obstacle. Even when the echo is not noticed, it affects the quality of the tone. The blind have learned to connect this quality of the tone with the different distances of objects, and guide their movements accordingly. When the boys in a blind asylum were provided with felt slippers in place of their heavy-soled shoes, they could not avoid obstacles with their usual skill. The footsteps were noiseless, and they were deprived of their most

important means of appreciating objects at a distance. It is said that the blind ordinarily refer their larger spaces to auditory qualities, as we refer them to vision. In all respects, perception of space by the ear follows the same law as perception by the eye or skin.

Perception of Time. — Much less is known definitely of the perception of time than of the perception of space. Time is much simpler than space. The statement is often made that time has but one dimension, while space has three. The idea of time reduces to before and after, together with the intervening duration. The most essential part of the idea is change, and the occasion for the appreciation of time is also change of some sort. Rhythmic changes in nature, the movements of the heavenly bodies or of pendulums, give the scientific means for the measurement of time. Similarly, psychological theories look to changes in the body for the explanation of our appreciation of time. Three ways of perceiving time may be distinguished. The first applies to times less than three-fourths of a second, the second to intervals from that up to three or four seconds, and the third to longer times. The shortest periods are immediately perceived in terms of rhythm. These times are overestimated.

Moderate Times Are Measured by Bodily Strains. — Intermediate periods are estimated in terms of bodily strains, particularly those involved in attention and the rhythmic bodily processes such as breathing. One easily made out is the strain of expectation that starts at the beginning of the first interval and increases in intensity until the end. It begins again with the second interval, and when it has reached the same intensity as at the end of the first interval, it is said that the second interval is equal

to the first. These periods of expectation do not ordinarily last more than three or four seconds without relaxation, and even at three seconds become very unpleasant. This is evident to any one who has watched the movement of a clock with a slow torsion pendulum or any similar slow rhythmic movement. The strain of waiting for the turn becomes unendurable after a short period.

Longer Times Estimated from Filling. — Periods longer than three or four seconds are estimated in terms of the events that fill them. Intervals in which much happens seem long, while those which have few incidents or are filled with the monotony of routine acts seem short. A month of the ordinary life seems no longer than a week of travel. This law of dependence upon the number of events holds primarily of time when considered in retrospect. When the time is passing, the greater the number of events, the shorter seems the time; while empty time seems very long.

Note

The difference probably is due to the different ways of measuring time. While one is merely waiting or is bored, one is constantly aware of the strain sensations that accompany expectation. In other words, empty time seems long as one lives it through, but when one looks back upon it afterward, no events stand out and the time appears short. Time filled with the ordinary routine seems short both in passing and in retrospect. One is too much interested to notice the strains that mark the passage of time, or else the strains do not have a chance to reach any marked intensity, because events succeed each other so closely, and later there is nothing to stand out prominently in memory. The apparent decrease in the length of the years with increasing age is an expression of this law. In early life, every event is new and seems important; as one grows older, less and

less attention is given to the routine of life, and in consequence the days and weeks seem less full. Strain sensations or the events that fill an interval furnish a basis for the perception of time. The idea which they suggest is a complex of experiences, based primarily upon change, but involving many experiences of motion, and even of space, that have slowly combined with them in a consistent, unitary whole. So far as the idea can be analyzed, it is on the same level as the idea of space.

Reading as an Illustration of Perception. — The perception of particular objects follows the same laws as these more general characteristics of all objects. One of the best illustrations of the perception of particular things is to be found in reading. Reading seems to be a process of taking words directly from the page to consciousness. Investigation of the reading process under various conditions has demonstrated, however, that one does not actually see all the letters or words that are read, but receives only suggestions of the words, and constructs or recalls them on the basis of these suggestions. In the ordinary connected reading the eye does not run slowly and regulraly across the line as is usually supposed, but moves by jumps and all reading is done during a few pauses. The number of these pauses is greater with less familiar matrial than with more familiar; there will be from three to six or more in the average length of line. The amount of material read at each pause is greater than can be attended to at a single glance. One must supply the rest. That misprints are frequently overlooked is also an indication that one receives but little from the page, and adds much from memory.

The Supplementation in Reading. — We find in reading both forms of supplementation mentioned at the beginning

of the chapter. The bare sensations have added to them single memory elements and earlier organized wholes of experience. The single letters seen suggest other letters previously associated with them; the letters or the form of the word suggest familiar whole words, and, at times, what is seen suggests particular and general ideas directly. Three forms of reading may be distinguished. These differ in the sensations that suggest the matter read, and in the material brought out to supplement the sensations. In one we read letters; in the second we read words; and in the third we read for sense, and neglect both letters and words. These three are frequently combined or mixed in practice. When reading the letters, as in proof reading, or in reading separate words, one usually sees only part of the word, and fills out the letters seen by associates. Thus if 't' is seen, one tends to supplement by 'h,' and 'l' is supplemented by 'y,' or other frequent associates; which of these associates it will be depends upon the environment or setting of the letter. If the letter 'l' is near the end of the word, it will be supplemented by 'y,' while some other supplement would be more likely at the beginning. These associations are subject to wider control, here as elsewhere. Letters read just before aid in determining the supplementation. Even more general contexts will have a part in the process. If one is reading German words, one sort of associates will predominate; if French, another sort. Often the word is read from its general form, and the letters known to compose the word are supplied later. One may at a second glance look to see if the letter suspected is actually present, and in the right place. Even in reading for letters, association is important; the operation is not one of seeing alone.

Reading Words and Reading for the Sense. — The associative processes have a more important rôle in reading words, whether in connected discourse or singly. Here, what is seen clearly is the form of the word with a few letters, and these serve to call up the whole word. That one usually reads words rather than series of letters is indicated by the fact that one can read short words more quickly than single letters. The word form, with or without the initial letters, suggests the word by the laws of association, but the associates are controlled by the context and setting. A form that in one connection suggests 'there' will in another setting suggest 'these' just as certainly and quickly. One selects the word that makes sense in the particular context, and, if one mistakes the context, may supply a word that is not present, or change the word that is seen to another which fits the context. The more usual form of reading, however, is neither of letters nor of words, but of ideas. As one reads, one sees in the mind's eye the scenes that the author describes; the words are overlooked or neglected. This reading for sense or for meaning follows the same laws as other forms of reading. The visual impressions have been connected with ideas, and selection is made from the ideas in accordance with the context, with what has been read, and with the expectation of what the author intends to say. The fact that the same word may have different meanings in different contexts without any interference of one meaning with the other is an illustration, at once of the dominance of the idea, and of the importance of the context in selecting the idea. 'Lead' is a verb in one context and a noun in another, but one never thinks of the noun when the verb is intended. The idea that is suggested is entirely different in the two contexts,

and the idea alone is important. It is because one is so much more concerned with the idea than with the letters or words, that one so seldom distinguishes between what is actually received from sensation and what is added to interpret the sensations. One is intent upon knowing what the author is saying, not how one knows it; the ideas are appreciated, not the process of receiving them.

As this page is read, the eyes dart from point to point on each line, making perhaps five pauses to take in the general form of the words and an occasional letter. These sensations suggest familiar words or familiar ideas, and the suggestions are controlled by the context and the appreciation of what is to be discussed. As a result, you construct for yourself the ideas that I have in mind as I write. You are aware of the ideas; it is only when some new word is introduced, or the statements are not clear, that you become aware of the words. All other perceptions follow these same laws. In listening to spoken words, you appreciate the ideas, not the sounds. Sometimes when one is listening to a language more familiar in print than in speech, one translates the sounds into visual pictures before one understands, just as in the early stages of reading one may translate the words seen into spoken words before they are understood. In both instances one usually translates into ideas at once. Other objects are perceived in the same way and by the same laws. Any object gives a few sensations that correspond to the letters or form of the words, while the object that is seen corresponds to the words or to the ideas that are read. The distinction between the mere sensations and the appreciated object cannot always be made out so clearly, but the same laws hold in the instances so far analyzed.

Optical Illusions. — One of the clearest demonstrations of the dependence of perception upon interpretation in the light of earlier experience is found in the fact and nature of illusions. In all forms of perception what is seen or heard frequently proves, on closer examination, not to be what it seems. Stimuli suggest the wrong memories or ideas, either because of close associations, or because the wrong context or setting is dominant at the moment. Optical illusions offer many curious instances of misinterpretation of space relations. One interpretation of a number of illusions is that they are due to a suggestion of perspective where it does not belong. Square surfaces are nearly always seen in perspective, which makes right angles appear to be either acute or obtuse. The most frequent association with these angles is a right angle, — an overestimation of the small and an underestimation of the large angle. Yet, small angles are not overestimated when seen alone. This association which has become fixed through the great preponderance of rectangular objects leads to error in many different cases. A circle with a square inscribed seems broken at the corners of the square, as may be seen in Fig-

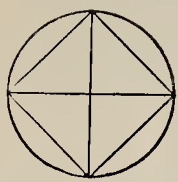

Fig. 32. — (From Titchener, *Experimental Psychology*.)

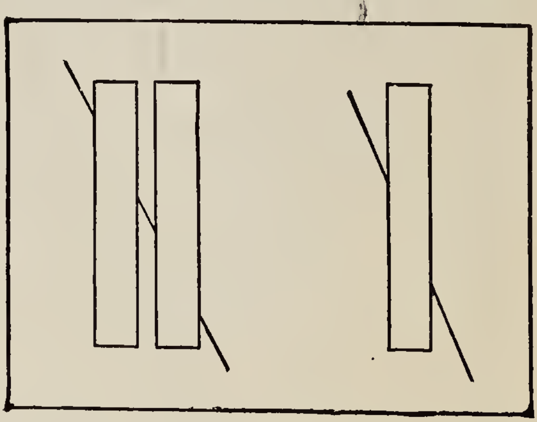

Fig. 33. — Poggendorff illusion. (From Titchener, *op. cit.*)

ure 32. Where an oblique line cuts a plane figure or two plane figures, the sections of the line seem not to be continuous. (See Fig. 33.) Both illusions can be referred to the overestimation of small angles. A more complicated

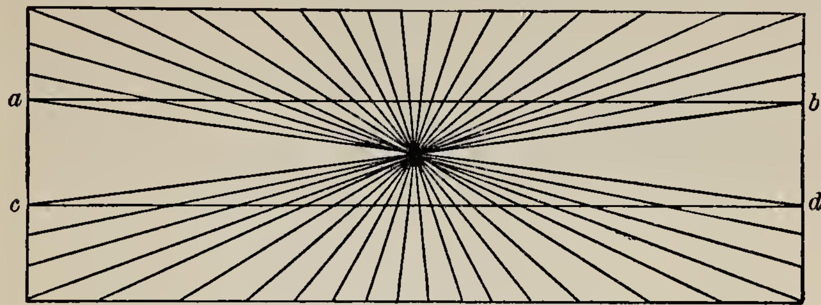

FIG. 34. — The Hering Figure. Lines (*ab*) and (*cd*) are really parallel. The oblique lines make them seem to diverge in the middle. (From Titchener, *op. cit.*)

figure, that may be explained as due to the overestimation of small angles or more directly as a misapplication of a perspective interpretation, is the Hering figure (Fig. 34). In this, the oblique lines are taken to represent parallel lines

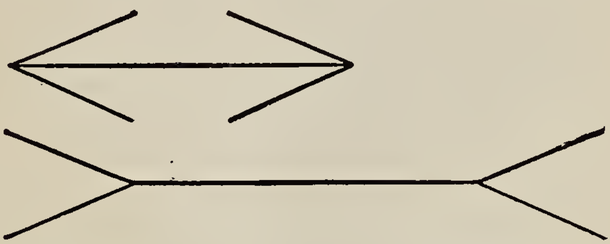

FIG. 35. — Müller-Lyer illusion. (From Titchener, *op. cit.*)

converging toward a vanishing point. As straight lines drawn on such surfaces would represent curved lines, the parallel lines are assumed to diverge in the middle. This, too, can be referred to the overestimation of small angles.

In all of these cases, the figure has been closely associated with the wrong interpretation, and the interpretation replaces the actual figure. Other illusions are apparently due to a comparison of parts of the figure that are not directly involved. The best known of these is the so-called arrow-head or Müller-Lyer figure (Fig. 35). The distance bounded by turned-out arrow-heads seems much larger than that bounded by those that turn in. It is probable that one really judges the enclosed area, rather than the distance from angle to angle. The perspective explanation has been applied to this figure also, on the assumption that one figure represents a book opened away from the observer, the other a book opened toward the observer. This makes one line seem more distant and thus larger than the other.

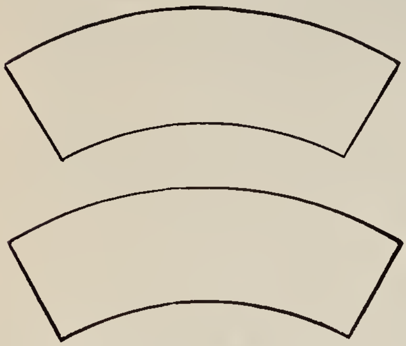

FIG. 36. — (From Titchener, *op. cit.*, after Wundt.)

Another illusion due to the surroundings is the underestimation of the upper of the two identical figures (Fig. 36). The upper one seems smaller because one expects both to be bounded by the same radii; the failure to extend to that line makes it seem shorter than the lower. A very large number of optical illusions are due to the effects of associations similarly misapplied, and a larger number may be brought under these two principles of misinterpretation of perspective, and of arousal of associates by the surroundings.

Illusions illustrating the same principle of the arousal of wrong associates may be found in any field. It has been

said that one frequently ascribes motion to the wrong object. When standing on a bridge over a rapidly flowing stream, one can easily believe that the bridge is moving upstream and the water is stationary. This is due to the fact that the smaller object is ordinarily in motion, the ground or the whole field of vision very seldom. The interpretation more frequently associated with the sensations asserts itself against the less frequent. The overlooking of misprints in reading has the same explanation, as has the shadow lines in the letters in Figure 26, page 210. Many misinterpretations of common objects can be referred to the same law. Illusions due to the dominance of the wrong context or to the wrong attitude are also numerous. If one is expecting any object, anything at all like it may be mistaken for it. When hunting for cows in the dark, any bush or dark spot takes on the form of the cow. Any preconception or situation that favours one interpretation is likely to arouse associates that constitute a misinterpretation or illusion. In general, illusions are due to wrong suggestions by sensations, either because of the greater strength of the inappropriate association, or because the wrong mental attitude is dominant. Illusions follow the same laws as perceptions; the only difference is that in the illusion the interpretation is proved false by later observation under more satisfactory conditions.

FIG. 37. — Shows that right angles seen in perspectives appear either as acute or obtuse angles.

Hallucination. — Hallucinations are closely related to illusions. Hallucinations have a slighter basis in sensation

than illusions, and derive more from recollection. An illusion is always a misinterpretation of an object, while in hallucination there is no apparent basis for the perception in sensation. It is probable that the absence of sensation is in most cases only apparent, and that the sensational basis may be found in some slight stimulation, as in the after-image for the visual hallucination, and in the circulation or some abnormal condition of the middle ear for auditory hallucination. Even in the insane, who are most subject to hallucination, there is considerable evidence that the presence of the false experience is determined by some obscure stimulation of a sense-organ which is misinterpreted and referred to the outer world. Thus a patient may insist that he is constantly hearing voices when no one else hears them, and with no apparent cause. On examination it is found that he suffers from a disease of the ear that produces a constant ringing in the ear, and this has been misinterpreted to give rise to the hallucination. The only difference between this and an illusion is that the illusion is excited by some slight objective sound, as when one mistakes the rustling of leaves for an approaching car.

Summary. — Perception in all of its phases, then, is due to the interpretation of present sensations by organized earlier experiences. The character of the perception depends upon the sensory stimulus, the developed ideas the individual has at his command, and the connection between these and the sensations. The entrance of the sensory stimulus and the decision as to which of the many possible additions shall be made to it depends upon the mental attitude and the wider situation of the moment. This dependence upon the whole has been emphasized especially by a recent school. They take their name, Con-

figurationists or the 'Gestalt' school, from this fact, that they insist that the figure as a whole determines the character of its parts. In all cases of perception, the result is accepted as a thing in the outside world, and this, the final outcome of the process, is the only part that is noticed; all else is overlooked. Finish for Dec. 3 N.B.

QUESTIONS

1. How is a percept different from a sensation?
2. What do associates add to perception?
3. Why do you see the same thing differently at different times? What changes?
4. In what ways are things different from percepts? from sensations?
5. Is space a thing? If not, how are the two related?
6. What is a 'local sign'?
7. Describe the mechanism by which the lens accommodates itself to different distances.
8. Why are two eyes more accurate than one in estimating distances?
9. Do you see double images ordinarily? If not, what influence have they in distance perception? If you answer 'yes,' in what sense do you use the term 'see'?
10. How does the estimation of the direction of a sound differ in the two different planes: the vertical between the ears and the vertical through the ears?
11. Illustrate from reading the three processes of perception.
12. In what two ways do we estimate the length of a time interval?
13. What are the possible misplaced associates in the Müller-Lyer illusion?
14. Explain the illusion in Figure 31.

EXERCISES

1. Move the finger in a circle before the face with closed eyes. Do you appreciate the motion in the arm or do you see it with the mind's eye? How is the picture suggested?

2. Have some one touch you on the wrist while the eyes are closed. Try to touch the point. Measure the error and repeat twenty times. Average. Is the first touch more or less accurate than the point finally decided upon? How do you know what point was touched?

3. Compare two lines 20 and 21 mm. in length. Can you tell which is the longer? Do the eyes move in the comparison? Can you compare with the eyes stationary?

4. Draw a horizontal line 20 mm. long. Without measuring, try to place a point 20 mm. above one end of the line. Measure the distance. Repeat twenty times. Average. Explain result. Repeat, putting the point above the center of the line. How do the results compare? Explain the difference.

5. Wave a candle or incandescent electric lamp about to one side of the line of sight in an otherwise dark room. Note the shadows of the retinal blood vessels. Why are they seen outside of the eye? Can you change their apparent position by looking at different distances? Why?

6. Hold a bottle with a label on it about 30 cm. before the nose. Close first one eye, then the other. Note the difference in the images. Place the bottle six meters away. Compare the images as before. Where is the difference between the images greater? Can you see the difference in the images with both eyes open? What is the bearing upon the perception of distance?

7. Hold the index fingers 25 cm. apart before the eyes. Look at the more distant finger and note the double images of the nearer. Close one eye. Which image vanishes? Look at the nearer finger. Which image of the more remote finger vanishes when one eye is closed? Look at a point 6 m. distant. Can you notice the double images of nearer and more remote objects? How do the double images vary in distance from each other as they depart from the point of fixation?

8. Have some one tap at the beginning and end of a two-second interval and then try to reproduce the interval as some one notes the time with a stop watch. How accurate are you? Can you notice any changes within your body that you use as a measure? Do you know that you use them in the estimate of the time?

9. Give a group of students first a period of twenty seconds while they are to do a simple arithmetical problem that can be completed

with time to spare, then give them a difficult problem that cannot be finished before the time is up and stop them at the end of the twenty seconds. Which seems the longer interval? Explain.

10. Place a mirror on one page of an open book and in it watch the eye of a man as he reads the other page. Count the number of pauses that the eye makes in a line and average. Compare the number of pauses when reading an unfamiliar passage in this text with those required in reading a newspaper. Try when reading to detect misprints. In which case are the words prominent as compared with the ideas?

11. Did you catch the misprints in the second paragraph on p. 234? If not, read again and note how many readings are necessary to detect them. Why did you replace the letters actually present by those that should have been there?

12. Draw a vertical line and then a vertical line across it. Can you see the figure as a cross with the arm at right angles to the upright, but in some other than the plane of the paper? How does this explain the overestimation of small angles?

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omit

CHAPTER IX

MEMORY AND IMAGINATION

One of the striking facts that have led men to an interest in psychology is the ability to recall and to make use of past experiences. This ability attracts attention because of its variability both from individual to individual and in the same individual from time to time. You remember what your neighbour forgets. You forget to-day what you remembered yesterday. You fail to learn to-day after an amount of study that yesterday was entirely sufficient for adequate recall. This uncertainty has made studies in methods of acquiring a good memory popular from the very early times.

Memory involves imagery and the laws of association. It is related to these processes very much as is perception to sensation. In memory we are considering the way in which we recall real things, while in the earlier chapter we were discussing the general laws of connection of mental elements that applied to all mental operations. The three mental processes that make use of earlier acquired knowledge are memory, imagination, and reasoning. These differ primarily in the attitude taken towards knowledge when it is revived. In memory we accept the recalled event as having been experienced as it is remembered. It is old and was actually known. In imagining we are aware that we are making a reconstruction of experience that may or may not be true, while in reasoning we believe the product

to be new and also assume that it will hold of actual events. Otherwise they are not to be distinguished. Each may be made up of the same elements. One may imagine an event, later reason that it is sure to happen, have this conclusion confirmed by the outcome, and later remember it, — all in the same imagery. They are all three suggested and determined in their course by the laws of association. Not the materials or the origin distinguish these states from each other, but the attitude taken toward them and the points in time and space to which they are referred.

The Phases of the Memory Process. — Memory is a reinstatement of an old experience with a belief that it is old and a reference to the period of its first appearance. We may distinguish four stages in a complete memory: learning, retention, recall, and recognition. Learning arises with the impression of the knowledge; retention depends upon the persistence of the effects of the impression; recall is the reinstatement through association of the original experience, while in recognition the memory is assigned to the specific time and place of the original event. These part processes are closely interdependent. Learning without retention is inconceivable, and retention can be demonstrated only through recall. The knowledge stored in your brain at this moment gives no sign of its presence. You can be aware of what you know only by recalling it. Finally, if events when recalled were not recognized, recall would be valueless. If when an idea came to mind you could not say whether it was derived from a dream or a real experience, it would be merely confusing. Statements that you remember to have read but cannot refer to a definite book or time can be little relied upon. Each of these processes must be taken up in order.

Observational Memory. — Two types of material have been used by the psychologist in experiments on memory: objects as they are presented immediately in perception on the one hand, and words on the other. The former are at times shown without warning that they are to be recalled. The first type is called observational or incidental memory, the latter verbal or rote memory. The former is used much in daily life and is tested by the testimony of the witness before a court. The latter is more used in school work. The experiments on observational memory consist in showing a group of objects or a picture and asking for a report upon what has been seen after intervals of different lengths. In other experiments, which more nearly approximate the conditions of cases in court, a scene is enacted and the report is upon that. In both types record is made of the proportion of errors made in the recall and what aspects of the objects are most easily mistaken in recall.

The Fidelity of Testimony. — Recall in incidental memory depends upon three factors: the accuracy of observation, completeness of retention, and the adequacy of recall. The first varies with the direction of attention and the correctness of interpretation. Attention, as has been shown, is determined by the earlier training and the momentary attitude. The observer sees what will answer his specific questions at the moment or what earlier experience has shown to be important. What questions are uppermost is also affected by the training, particular or general. As a rule, all are more likely to notice persons and their acts and objects. Less likely to impress one are space relations and colours. From eighty to ninety per cent of correct answers will be made concerning persons and objects as compared with forty or fifty per cent for the number of objects or for

colours. Younger children notice persons and other objects alone. As they grow older, they begin to observe space relations and numbers and finally colours.

One who has had experience with the experiments will look for the phases which he has found are most likely to be mistaken. He will count the number of windows in a building at the time of exposure or ask himself what the colours are. He will formulate the answers in words and remember those, for he knows he will make fewer mistakes than if he trusts to the vaguer sensory images. The rate of forgetting for this incidental memory is relatively slow, especially for the answers that are formulated in words. Stern and Miss Borst found that the increase in errors is about one-third of one per cent a day. Dallenbach on the other hand found that there was a relatively rapid decline in accuracy at first and that it then became more gradual. He also found a more rapid forgetting than Stern. Immediately after exposure, ten per cent errors were made; this had increased to fourteen per cent after five days; after fifteen days, to eighteen, and after forty-five days, to twenty-two per cent.

Errors from Suggestion at the Time of Recall. — Especially important are the errors due to forces active at the time of recall. In giving a report of what has been seen, there is always a tendency to add to the actual observation what is only inferred. These additions are supplied by suggestion and are mistaken for real memories. Questions greatly increase this tendency since they suggest objects which are either not observed or only vaguely remembered. When left free to describe an experience in his own way, the individual makes from ten to twenty-five per cent fewer mistakes than when questioned, even when the questions

are as free from suggestions as possible. When the question intimates what the answer should be, is what the lawyer calls 'leading,' the number is greatly increased. If a picture is shown to a class and they are later asked to tell the colour of the dog lying before the fire when there is no dog in the picture, as many as twenty per cent may comply. Children are much more influenced by suggestion than adults and so their testimony is much less to be relied upon. The same holds of a witness on the stand. Cross questioning always decreases the accuracy, since the questions suggest what is not really remembered, and the ideas suggested are believed to be actually recalled. On the other hand, it brings out points that would not be thought of unaided and so is necessary. It may also be added that subjective assurance is not a satisfactory warrant for truth. Statement under oath is only a little more correct than ordinary assertion.

Rote and Logical Memory. — In school life we put most emphasis upon the retention and recall of events as described in words. Written and spoken words have so large a place in school and in social life in general that verbal memory is assumed to include all memory. In dealing with it we may disregard the errors of observation and emphasize the real memory processes. In all discussions, it is essential to recognize two distinct forms, rote memory and logical memory. In rote learning connections are formed between the successive ideas or elements to be learned, and recall is always from one to another of these elements. In logical learning, on the contrary, the material to be learned is connected with the organized knowledge of the individual; it is understood, and learned because it is understood. Most learning in everyday life is of the logical sort. We

acquire ideas, not mere words, and the ideas are assimilated at once with the ordered experiences. This is much quicker and more effective than rote learning. We must consider both these forms of learning in each stage of the memory process.

Experimental Methods. — Most of the experimental work in memory, of which there has been a great volume in recent years, has dealt with rote learning. Nonsense syllables were chosen as the material to be learned in these experiments, since these were entirely new to the learners and hence should be equally easy for all. Nonsense syllables were made by placing a vowel between pairs of consonants and eliminating all of the combinations that made words. From these syllables series of from eight to sixteen were chosen and shown to the learner at regular intervals. The number of times the series were shown was recorded. Tests as to the amount retained were made after different intervals to measure the amount of retention, and thus to determine the relative value of the methods of learning. A large number of results have been obtained from these experiments, and we can profitably begin our discussion of the memory process by a summary of certain of the more important laws thus established.

The Laws of Learning. — Learning, the first step in memory, is only a process of forming associations. Rote learning is primarily a process of forming associations between series of words or events, — in the experiments we are considering, connections were formed between nonsense syllables. The experiments were devised to test the best methods of establishing these connections and to determine the course of forgetting. The results may be stated in a series of brief laws.

1. **Retention Varies with Repetitions.** — Learning is directly proportional to the Number of repetitions. If four repetitions give a saving of two on relearning, eight will save four. Experiments show that between two and sixty-four repetitions, each repetition has the same effect in facilitating recall. In the experiments of Ebbinghaus the series could be learned in thirty-one repetitions. This means that more than double the number of repetitions just necessary to give perfect learning at the moment increase the possibility of recall. Recent experiments show that readings may be increased to the point where they give a reduced effect. This point varies with the subject and the material.

2. **Adults Learn More Quickly than Children.** — Capacity for learning increases with age up to twenty to twenty-five and then falls very gradually. Thorndike estimates that fundamental capacity for learning is about thirteen per cent less at forty-five to fifty than at the maximum. The loss is frequently compensated for by greater effort and interest. The popular belief that children learn more easily than adults seems to have no basis in fact. When tested in any accurate way, the child is found to learn with greater difficulty and to retain less than the adult.

3. **Distributed Repetitions More Effective than Accumulated.** — Learning is easier if the repetitions be distributed over several days, rather than accumulated on a single day. With twenty-four repetitions, two repetitions on each of twelve days are more effective than four repetitions on six days, or six on four days. Any distribution will be better than to have twenty-four on one day. In general the most effective distribution is one repetition every other day. This is due in large measure to a setting of association processes during the memory after-image, —

the continuance of the sensory process for a period after the stimulus has ceased to act. With one repetition a day, this setting during the fading of the impression occurs twenty-four times, while if you give the twenty-four repetitions on a single day there will be but one after effect and so but one setting. It is this that explains the common observation that learning a lesson on one day and then reviewing it the next gives a greater command of the material then spending more time on it at the first sitting. Divided repetitions show a more decided advantage for material that is to be remembered for weeks than for that to be retained but a day.

4. **Learning as a Whole versus Learning by Parts.** — In learning a selection, it is advisable to read through the whole from beginning to end, and to repeat the reading until all is learned, rather than to learn bit by bit. If one attempts to learn a poem line by line or stanza by stanza, one makes a number of unnecessary and misleading associations between the ends and the beginnings of lines that both waste time and interfere with the correct associations. Then, too, learning by parts leads to the repetition of the first portions more frequently than is necessary, since they are repeated with each of the later parts. The only objection to learning by wholes is that one is likely to lose interest in the work when no progress can be noticed, and to read more slowly than usual. This may be obviated by making pauses at the natural points of division without going back to the beginning. It is also advisable, after the selection is partly learned, to repeat the harder parts more frequently than the easier. These methods combine the marked advantage of learning as a whole with the greater interest that comes from observing progress in the task. When

this rule was observed, some investigators demonstrated a saving of from twenty to fifty per cent in the repetitions required for learning.

Limits to Learning as a Whole and by Spaced Repetitions. — Both of the two preceding laws hold as a rule particularly for easy or meaningful material. Certain exceptions may be noted and considered together, since the two methods mutually influence each other. Learning by parts seems to be more effective where the material is complicated and no meaning can be given it. Pechstein found that both rats and men learned complicated mazes best when given in small parts. Ephrussi found that nonsense syllables were learned more readily by the part method, while sense material was easier by the whole method. The parts must be learned all at one sitting, while learning as a whole is much easier if spread over several days. Learning as a whole is quicker when there is a thread of meaning or anything else that can be grasped running through the mass. Partial learning seems to give the same effect as meaning in favouring learning as a whole. When the material becomes clear enough to be anticipated, running through the entire mass seems to be more effective than learning by parts. The only experimental challenge of this statement is by Pechstein. Pechstein found that mazes were most easily learned by men and rats when they were divided into four parts, and each part learned separately by massed repetitions and then the four parts joined together by spaced repetitions. The compromise method united the advantages of both the others. Miss Hanawalt, who repeated Pechstein's experiment in a study as yet unpublished, found the direct contrary. With no group of rats nor by any method was the part learning so effective

as the whole. The mazes were more complicated than Pechstein's, but there seemed to be no other difference in the experiments. This leaves the question open again.

5. **Dependence upon Rate of Repetition.** — Learning is quickest if the rate of repetition is as fast as is convenient for the man who is learning. Slower repetitions waste time and permit distraction; faster distract attention from the learning to the articulation. As many as two hundred syllables a minute have been found most advantageous for some individuals. When a student has been compelled to postpone preparation of a lesson to a short period before the recitation, unexpected results are shown for the time spent. Rapid reading is of less value for material that requires thought than for rote learning. Slower reading permits the formation of more associates; rapid reading gives strong associations with the preceding and succeeding elements, but gives no time for others that might be important. Slow reading is better at first; more rapid, later, when the material has been partly learned. Naturally quick learners also retain a larger percentage of the material than the slow learners.

6. **Rhythm Aids Learning.** — Rhythm is a great aid to learning. It is difficult to avoid rhythm, and best results may be obtained from a rhythm adapted to the material and to the individual peculiarities of the learner. The strongest connections are made between the elements of the rhythmic unit. When the rhythm is changed or elements are given a place in a new unit, relearning or retention is much interfered with. The importance of rhythm is shown by the ease with which blank verse may be learned.

7. Learning is much quicker if the material is repeated with the intention of recall. Sanford found that he could

remember very little of the Morning Prayer which he had read more than five thousand times. With the intention of recalling, twenty repetitions should, at a conservative estimate, give complete learning. Laboratory experiments in which material is read a number of times with the intention of seeing what associates are aroused or with any other intention than learning show that many readings give little or no signs of learning. The words may be recognized but will not be recalled.

8. **Attempted Recitation More Effective than Passive Reading.** — If one will try to repeat from memory after a minimum number of readings, learning will be completed more quickly than if one continues the passive readings. Gates found that four-fifths of the entire time used might to advantage be devoted to attempting to recall. Attempts to recall should begin as soon as anything is learned. Skaggs found that they might well be alternated with readings. The advantage of recitation comes from greater attention during the active process.

9. **Associative Inhibition.** — Ideas learned in one connection seem to be more difficult to learn in another connection. If idea '*A*' has been learned in connection with an idea '*B*,' it will be more difficult to learn it in connection with another idea '*C*,' than if the other association had not been formed. Learning anything incorrectly makes correct learning more difficult. The wrong associations check the formation of the correct associates. Associative inhibition is present only when the first set of associations has not been completely formed. After complete learning, the one set of associations may make easier the formation of others of the same kind. If, for example, one has partly learned one style of typewriter keyboard, it is much more difficult

to learn another; but if the first has been thoroughly learned before one begins the second, the second will be learned more quickly than the first. The same holds in some degree of learning languages. It is wise not to begin two languages at the same time.

10. Zeigarnik of the Gestalt school has recently shown that an uncompleted task is more readily remembered than a completed one. The tasks varied from drawing a figure, learning a selection, to repeating a poem, etc. About half of the tasks were left uncompleted, the rest finished. Later when the worker was asked to name the tasks he had been busy with, it was found that he recalled about sixty per cent of the unfinished ones and only about forty of the completed. A finished task drops from mind, while the uncompleted one continues in the perseveration phase ready to be brought to conclusion.

All learning, then, is a process of forming associations; and all rote learning, with much of other learning, depends for its adequacy upon the use of suitable methods of repetition. To translate into nervous terms, learning is a process of producing changes in the synapses. This change depends directly upon the number of repetitions, upon the age of the individual, upon the time that elapses before one repetition is succeeded by another, and by the rhythm and rate of repetitions. Proper control of these factors and of attention gives the means of easiest and most complete learning.

RETENTION AND FORGETTING

If learning is the result of producing changes in the synapses, retention depends upon the persistence of the impression, forgetting, upon its disappearance. That the impressions fade and gradually disappear with the passage

of time is obvious, but the rate of disappearance and the conditions that favour or retard the disappearance can be determined only by experiments. The same procedure that gave us the laws of learning has also developed a series of laws of forgetting. We may summarize these as before.

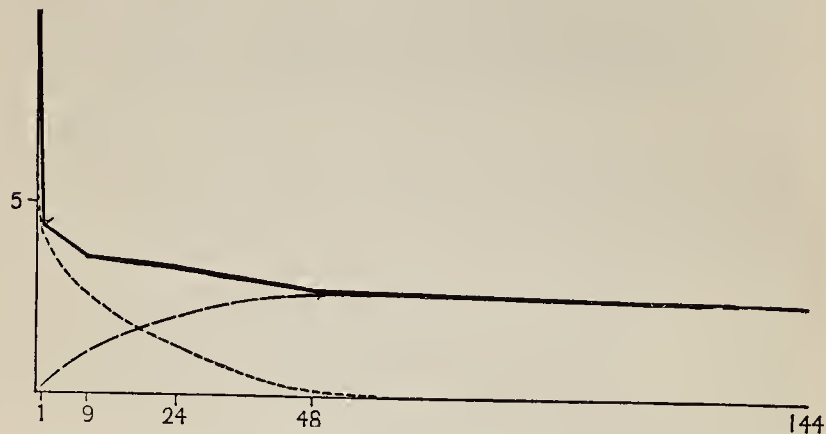

FIG. 38.—Shows the curve of forgetting according to Ebbinghaus. The figures on the lower line indicate the hours since learning. The upper heavy line shows the percentage of material learned retained. The dotted line indicates the theoretical line of decrease in perseveration. The longer broken line, the probable curve of the strength of association.

1. **Rate of Forgetting.** — Forgetting goes on very rapidly at first, then more slowly, until finally there is no appreciable change even over long periods of time. Ebbinghaus found that with series of nonsense syllables, half of the learning was lost in the first hour; two-thirds the first day; while at the end of the month, less than four-fifths was forgotten. Radossawljewitsch obtained the same general law, but with a slower rate of forgetting for the shorter periods. In the experiments, the amount of forgetting is measured by comparing the number of repetitions needed for relearning after the lapse of some definite time with the number

of repetitions used in the original learning. Thus, if sixteen repetitions are required for learning a series of twelve syllables, eight repetitions may be necessary to relearn at the end of the hour. After three days, no single one of the syllables can be recalled off-hand, but all can be relearned in ten repetitions.

One may have forgotten all about a method in arithmetic, but will find that it can be relearned in a fraction of the time originally given it. Not a little of the benefit of learning lies in this increased ease of relearning, even where nothing can be recalled spontaneously. Forgetting is much slower for sense material than for nonsense. Ebbinghaus found that half was retained at the end of twenty-four hours, as compared with one-third for nonsense syllables. He was able to demonstrate a saving of seven per cent in relearning poetry after the lapse of twenty-one years.

2. **Improvement as Well as Forgetting after Learning.** — Several phenomena indicate that there may be a tendency to improvement in learning with lapse of time after repetitions. Ballard found that children even up to twelve years old could repeat more lines of a poem a day or two after they had learned it than they could immediately. This would seem to indicate that with sense material children really increased rather than diminished their knowledge of the material learned during the next few days. We can connect this with the tendency to 'set' during the period of the perseveration or memory after-image that was used to explain the influence of distributed repetitions. It will also be used to explain retroactive inhibition in the next paragraph. In the figure above (Fig. 37), it is schematically shown that forgetting is a balance between two tendencies, the reduction in the memory after-image and the

fixation of association bonds while that primary memory process is dying away. While the effects of the repetition still linger, the association increases in strength. Usually the dropping down of perseveration is much greater than the increase in association. In children under certain circumstances, it seems that the balance is a gain for memory rather than a loss.[1] This may be connected with Jaensch's result that children have stronger eidetic imagery or perseveration than adults.

3. **Retroactive Inhibition.** — After learning, the degree of retention is affected by mental activity of any sort. If, after learning a series of nonsense syllables, one turns at once to learning something else or to any other form of mental work, retention is sometimes less complete than if one rests a few minutes. The new work seems to interfere with some continuing activity of the nervous system that is essential to the best retention. This 'setting' of the associations after learning is probably what makes distributed repetitions more effective than accumulated ones. It is also connected with the memory after-image, that has been mentioned in previous chapters (*vide*, p. 161). The nerve-cells continue to act for some little time after the conscious processes have ceased and the associations increase in strength during this period. New work interferes with this activity, and prevents the associations from reaching their full strength. This so-called retroactive inhibition is analogous to the retrograde amnesia of the psychiatrist. This technical term is given to cases in which a mental or physical shock destroys all memories of immediately preceding events which may be assumed to be represented by asso-

[1] Ballard: "Oblivescence and Reminiscence, *Brit. Journ. of Psychology;* Mon. Supplements, vol. i.

ciations that have not completely 'set.' A blow upon the head often obliterates the memories of events that have occurred during the preceding half hour or so. An emotional shock may have the same effect. In our present connection, hard mental work exerts the same influence in smaller degree. A lesson will be better remembered, if one will wait three to six minutes after finishing it before turning to another task.

4. **Quick Learners Forget Slowly.** — Individuals who learn easily forget slowly, while those who learn slowly forget rapidly. This law holds if one considers pure rote learning. When learning sense material by logical connections, the man who learns slowly may have an advantage if he gives the added time to understanding the matter. In this case the evidence shows that slow learning is compensated for by retentive memory. The conditions and results are somewhat in dispute.

All learning and retention, then, are dependent upon the formation and persistence of associations. Learning and retention are never of ideas or things in isolation, but always of things in connection. The only laws that affect learning are the laws for the easy and quick formation of associations, and for preventing interference with them when they are formed. No new principles need be added to the discussion of association to understand rote learning and retention.

The Advantages of Forgetting. — One is inclined to think of forgetting as altogether a disadvantage. A little consideration shows that on the contrary, if everything were remembered, it would probably be a great misfortune. Many of the trivial events of everyday life are very much better forgotten. Forgetting is an expression of the selective activities of consciousness, and is almost if not quite as

important as attention in protecting the individual against the unessential details. Attention very largely determines what shall be selected, both for observation and retention, although it may work different results for each. Many things important at the moment are not worth recalling. Forgetting plays its part in permitting these to lapse into unconsciousness. A good memory involves a certain amount of forgetting, provided only the right things are forgotten. Not only is it an advantage to forget the trivial events but also to forget things that were learned wrongly. If one remembered everything, the bad would survive with the good. As it is, when a mistake has been made and corrected, the correction may be remembered, the mistake forgotten. On the whole, then, the fact that the memory trace in the nervous system tends to disappear is an advantage rather than a disadvantage. In some cases where no distinction is made between the important and the unimportant, the individual is rendered ineffective. Slavery to detail often leads to waste of time and effort that a selective memory might prevent. In the adequate use of past experiences, forgetting is almost as important as remembering.

RECALL

The laws of recall, too, are primarily the laws of association. Just as everything that is acquired must be learned in connection with something else, so anything that is recalled must be recalled because of the rearousal of an associate. This can be brought about only through the presence of some cue, some idea associated with the fact essential at the moment. One cannot recall an idea without the associated idea or sensation. It is impossible to get back the fact in any other way than through the appro-

priate suggestion. This suggestion may be furnished by the preceding idea or it may come through sensation. Fortunately nearly every fact has been associated with the occasions that make its return desirable, and in consequence one never suffers from or even notices the lack of more direct means of recall. The desire for recall brings its satisfaction, and that is all that can be asked. The laws of recall come into prominence only when they fail to be effective. Occasionally one is certain that one has a bit of knowledge that would be desirable at the moment, but which cannot be recalled. Under such circumstances, one of two factors is at fault. Either no association has been formed between the idea in mind and the idea desired, or the mental attitude is wrong for developing that association. These are the conditions for the return of associations discussed in Chapter V. That one can be obviated only at the time the associations are formed is due to the nature of the learning; the other depends upon the condition of the thinker at the moment of recall.

The first of the two obstacles to recall can be obviated only by learning the fact in connection with all of the possible situations that may require its application. Most learning is in one connection only or in a few at most. The value of a fact increases with the number of connections that it makes, for each new connection makes it available in a new place and at a new time. These valuable connections can be supplied by taking time to think of the various uses that a new fact may have, or, more effectively, by actually applying it. A formula in trigonometry will be impressed much more surely and will be recalled in many more appropriate situations, if a number of problems are solved by it. Each of these applications, when they appear

in practice, will suggest the principle; while without them, only the preceding statements in the text will recall it, and these are seldom present when the principle is needed. In general, learning any new fact in all its useful connections will insure perfect recall, so far at least as it may be insured at the moment of learning.

Attitude Influences Recall. — The other element in recall depends upon having the correct attitude toward the situation when it presents itself. When one is looking at the problem from the wrong standpoint a number of solutions that harmonize with that attitude will present themselves, and prevent the desired solution from appearing. Both sorts of failure to recall may be observed in any class recitation. When a question is asked, it should serve as a cue for the answer. In many if not most cases, the failure to answer does not depend upon lack of knowledge, as is proved by the fact that the answer will be recognized when it is given. What is wrong is the failure to connect the answer with the question at the time it was learned. It was learned in some other connection, and is useless as an answer to this question. At other times, the question may be understood in the wrong way. The student is thinking of the question in one way, the instructor in another. The result is that the answer suggested does not meet the problem that the instructor has put. Adequate recall depends, first, upon having the material; then upon having the knowledge associated with an idea or object present when that bit of knowledge is needed; and finally, upon being in a suitable attitude toward the situation. The first two, learning and learning in the right connections, can of course be insured only before the time at which the knowledge is to be used. The attitude is the only factor determined at

the time of recall, and that is not easily controlled. It depends upon the agility of wit of the thinker, and upon the things he has been seeing or thinking just before. The most that can be done is to teach the individual to look at a situation in many ways. Taking the right attitude is in large part due to native endowment, but training or practice has some effect.

Confidence Facilitates Recall. — A third condition that favors recall, also active at the moment of recall, is confidence. If you believe fully that you know and can answer a question, you are more likely to succeed than if you are in doubt. Doubt, irrespective of the amount of preparation, seems to hinder reproduction. How to control faith in your memory is a problem. Something, of course, depends upon previous success and cannot well be changed. That it is the mood rather than the capacity that is responsible in many cases, is evident from the fact that temporary embarrassment, or other emotion, may induce a devastating doubt in a man who is ordinarily confident.

Reproductive Inhibition. — One factor similar to associative inhibition, that was considered in discussing learning, may affect recall. This is reproductive inhibition. Two or more associates with the same idea, not only mutually interfere with each other in the formation, but each also prevents the recall of the others. If one has learned '*A*' with '*B*,' '*C*,' and '*D*,' and '*A*' is in consciousness, the recall of any one of the associates may be prevented, or at least delayed. All associates tend to return, and each helps to prevent the return of the others. This mutual interference of associates is probably the explanation of many cases of mental blocking. Often when one is trying to recall a perfectly familiar fact, it refuses to

return. It seems to be on the tip of the tongue, but cannot be expressed. Later, when the occasion for its recall has passed, it will return with perfect ease. It is probable that the cue was associated with several ideas, and that they mutually prevented the return of any one. When recall occurs, probably all but one of the associates have ceased to be active. Ordinarily some one associate will be much stronger than the others, or will be favoured by the context or 'mental set,' and the opposition of the others is ineffective.

LOGICAL MEMORY

Logical Learning Involves Principles. — So far, we have been discussing memory as if all associations were formed at once, and as if all learning dealt with entirely new knowledge. As a matter of fact, however, most learning consists in bringing the new material into connection with old knowledge, or in seeing old knowledge in new lights. When one is reading even in a new subject, one is constantly referring what is read to earlier knowledge, rather than taking the new as new. We can bring ourselves to read very little of what we do not understand, yet to understand means nothing more than to refer the new to old knowledge or old principles. What is understood is learned very quickly, — even by a single repetition. A large part of the work necessary for learning was done when the principles themselves were learned and does not need to be done again. All that is necessary is to connect the new with the old, and the new then takes on the permanence of the old.

The advantages of logical learning are twofold. In the first place, as was indicated above, when one understands, the material is partly known already, and so needs fewer repetitions to be remembered. In the second place, there

are many more facts than principles, and the principles are used so frequently in different connections that they become part of the permanent endowment. Specific instances may appear and be forgotten, but the general principles illustrated are used over and over and thus are given no chance to be forgotten. When the new fact or experience is understood by being referred to this system of principles, it, too, comes to partake somewhat of their permanent character. One may notice in the simplest affairs the difference between the bare unaided memory and this memory of general principles. In playing golf, for example, one may either remember in a vague general way where the ball has been driven, or may fix the place by specific reference to a prominent object. If one merely notices, one may at once walk to the ball with no other thought than that one is going in the right direction. Under ordinary circumstances this suffices, but if one is turned aside to hunt the ball of the opponent, or the stroke is bad and arouses an emotion, the pure, unmediated memory is destroyed; one retains but the vaguest idea of the direction of the ball. If, however, one refers the ball to some tree or bunker, refers it to a familiar system, the position will be remembered in spite of distraction, and for a considerably longer time.

Logical Learning More Rapid and More Permanent. — Nearly all of the experiments whose results have been formulated in the earlier sections, have been made with nonsense syllables. Similar experiments with sense material, learned as one ordinarily does, for ideas rather than for words, show that the laws stated above are true for logical as well as for rote memory. The most striking difference between the two forms is the greater ease and permanence of logical learning. Ebbinghaus found that learning poetry

verbatim takes less than half the time required for nonsense syllables, but memory for the sense of ordinary reading matter has a much greater advantage. Long passages that would require days for their verbatim learning can be appreciated and the ideas retained with one reading. The rate of forgetting is also much slower. A fact thoroughly understood may be remembered for most of a lifetime. Accurate experiments on the course of recognition indicate that objects, that may be referred to standards or general principles, are recognized practically as well after a longer as after a shorter time, while sensations, to which no names can be given or which can be referred to no general principle, lose their value for recognition at about the same rate as that at which nonsense syllables are forgotten. What experimental evidence there is, together with the results of observation, indicates that logical learning is very much quicker than learning of nonsense syllables, and that the material is much more slowly forgotten. Most learning is of ideas, which are learned in connection with principles already known rather than by the bare laws of association. In consequence, the usual learning is much quicker and forgetting much slower than the results obtained from experiments on nonsense syllables indicate. The one important difference is that what is essential in logical learning is the formation of associations between the new and the general principles that explain them, rather than the formation of associations between successive elements.

Cramming. — Recent investigations throw considerable light upon the old problem of cramming. Cramming is essentially a process of learning by accumulated repetitions. In recent experiments upon material learned for its ideas rather then for the words, accumulated repetitions gave as

good results as distributed when tested twenty-four hours later, while the divided repetitions were much more effective after two weeks or a month. This harmonizes with the common experience that material studied intensively just before one needs to use it can be recalled fairly accurately, but leaves no permanent impression; while matter learned by various repetitions during the term, even if it be no better recalled at the time of examination, will be remembered for a long time. Frequent reviews are very valuable for the permanent retention. Edwards found that four minutes' study of a short selection with two and a half minutes' review a few days later gave thirty per cent more correct responses than six and a half minutes' study at the first sitting. In addition to the probably physiological effect of divided repetitions, frequent return to a topic makes it possible to relate it to many different facts and thus increases the number of events that will arouse it. Then, too, the definite intention to learn anything for a particular occasion seems to give a tendency for it to be forgotten when that occasion is past. Cramming for these reasons gives only temporary retention. Lasting knowledge demands faithful work day by day and frequent reviews.

General Principles Retained Longer than Particular Facts. — Evidence for the advantages of logical learning and the great value of a background of organized knowledge may be obtained from a study of the decay of memory. The more general ideas vie with the earliest acquired in being the last to be lost. The aged remember the general principles and the events of childhood long after particular memories and recent events have vanished. In brain diseases of different origins the same law holds. Common nouns are remembered after proper nouns are forgotten;

verbs are retained longer than nouns, and gestures persist when words have been forgotten. The reason may be found in the greater chance for the general terms to grow into the nervous system. The general terms and general principles have been used hundreds of times where particulars have been used once. Each use makes the habit of using it stronger and increases the likelihood of recall on new occasions. The same factors that make these fundamental principles permanent in the memory of the normal individual and make them so important as points of reference also make them the last to disappear with the degeneration of nervous tissue in disease and old age.

Logical Memory Is of Meaning. — Not only the methods of remembering, but the content, are different in logical memory. One thinks of remembering as a process of reinstating an experience in its original form. As a matter of fact, however, one does not generally have an image reinstated that is like the original experience. It need only mean the same thing. The image is modified by all that has been seen in that connection since the former experience. One nearly always remembers the event, not as it actually was, but as it must have been in the light of what has been experienced before and after. One interprets the experience in terms of the system of knowledge, and the system modifies the images that are recalled. Reasoning and memory combine in the construction of the recalled image. Still more frequently, no very specific image is reinstated; one remembers, not the event itself, but that the event happened. The imagery involved in remembering that a thing happened is perhaps some symbol of the event, or some general symbol, plus the associations that connect it with a specific time; the image is lost in its meaning, in

the fact that it represents. The image itself is not attended to, and one cannot say, after the experience has been recalled, what the image was in itself. This sort of recall is closely related to reasoning, and the process can be understood better after the discussion of meaning in the next chapter. Suffice it now to say that the memory is usually, not of images, but of meanings.

RECOGNITION

Forms of Recognition. — After recall comes recognition. Recognition may be defined as an awareness of the time and place of origin of the memory image. Both objects and ideas are recognized, and recognized in the same way. One meets a friend of earlier years, and immediately or after some thought can refer him to a definite place and to a definite time in the past. Similarly an idea may float into memory and either be recognized as a fact read in a school book, or be referred vaguely to the past without specific knowledge of its warrant or of its authority. The explanation of recognition is the same for ideas and for objects. The process can be studied most easily in connection with the delayed or indirect recognition. Frequently one sees an object, and is at first uncertain where it has been seen before or what it is. Gradually other ideas cluster about it. As the new object suggests old ones, the new begins to seem familiar, and finally is completely recognized. Then it takes its place with the ideas that have themselves been recognized. One may see an animal and feel that it is of a familiar species, but not remember what it is. The object suggests a setting in which it was seen before, and that may suggest the name that a friend gave to it at the time, or the picture of the animal in the volume in which it was looked up after

it had been seen. A face may be recognized in the same way. The face seems familiar, but the name cannot be given nor the place where it was seen. Gradually a cluster of memories groups about the face, — the background of a familiar room where the man was seen, or the class room where he had been sitting; then the name or other explanatory ideas come up, and recognition is complete. In general, then, this delayed or mediate recognition is always due to associates aroused by the object or idea, when it presents itself to consciousness.

Mechanism of Immediate Recognition. — When recognition is immediate, one knows at once that the object is familiar but there is no evidence of the nature of the process. The idea or thing is accepted and that is all there is to it. This is the more usual sort of recognition. One knows nothing of how a close friend is recognized, or of how one tells one's own text-book from one's neighbour's. It is pretty clear from experiment and observation that the process is in part the same as in mediate and delayed recognition. Associates are aroused as before, but they come at once and do not attract attention for themselves. They give evidence of their presence only by the fact that the object is recognized. When the very familiar object presents itself, there is a rush of associates, or the opening of a number of association paths that bring the recognition with them.

Habitual Movements Important in Recognition. — Simple recognition may be almost entirely a motor process. Many objects arouse movements immediately and these give rise to an awareness that the object is familiar. One knows one's own fountain-pen by the fact that the movements that it excites are suited to the pen; there is no hesi-

tation or false adjustment. When a friend's pen has been picked up by mistake, one becomes aware of the mistake by the awkwardness of the movements. The position of the fingers, that is best for the familiar pen, makes the new one scratch, or it fails in some other way to respond as the old one does. Part of the recognition of an object that is not handled or that does not give rise directly to movements is due to the fact that its uses are appreciated, that when it is recognized, one knows at once what to do with it and how to use it. As a result of the associates and of the smoothness in the actual and the intended or possible movements, the old object ordinarily arouses a feeling of pleasure, while the unfamiliar is nearly always unpleasant. Possibly one may assume a peculiar feeling of recognition in addition to the pleasure, but this is less easy to be sure of than the fact of recognition. Three factors contribute to the process of recognition. First, the arousal of associates; second, the excitation of familiar movements; third, pleasantness, — a result of these two processes.

Recognition a Reference to the System of Knowledge. — One question that is at once suggested in this connection is why the arousal of old associates should tell what the object is and where it was seen before. Part of the answer is found in the fact that the associates themselves are recognized. If each associate must be recognized by other associates, the process would become interminable and compel one to run through the experiences of the individual from the time of the event recognized to the present moment. This is evidently never necessary; at most one or two sets of associates suffice for complete recognition. The reason is that we make use of the system of knowledge in recognition as in learning and retention. One refers the new to

the developed system. When the new arouses an element of this system, recognition is complete. In other instances what we call recognition is nothing more than reference of the new thing to a general class. We recognize a small animal as a weasel when we can classify it; there is no implication that it has ever been seen before. This classification is only a reference to our system of zoölogical knowledge. Similarly, prominent events in life constitute a framework for the recognition of new events. These may be the places in which one has lived, or the different stages in the school life which serve for the recognition of personal events, as do the kings of England as points of reference for all other events of modern history, or the succession of reigns in Rome for ancient history. Any event is placed when it is known to have been related to or contemporaneous with one of these landmarks. To understand, and to recognize in this way are very closely related operations. Each consists in being referred to the framework of knowledge or to the system of prominent events.

Paramnesia. — Paramnesia, an interesting illusion of recognition, throws much light upon its nature. One occasionally feels, when in a new place, that one has been there before. The whole setting and many of the details of the place are familiar, yet one is certain that this is the first visit. Plato described the experience and used it in support of his theory of the transmigration of souls. He argued that the recognition indicated that the place had been visited in an earlier existence. As a matter of fact, however, the explanation is to be found in a misplaced recognition. Some parts of the situation are similar to old situations. These serve to arouse associates which give rise to a feeling of familiarity, and this feeling extends from the part to the

whole. The illusion illustrates the dependence of recognition upon association and related psychological processes. The old is not recognized where these processes are lacking, and the new seems familiar when by chance they are called out where they do not belong.

The Best Methods of Remembering. — Since the ancients, many attempts have been made to find easy and certain ways of learning and remembering, and in all ages there have been individuals who profess to have methods for improving the memory. All of these attempt to make use of special methods in forming associations. They fall into two general classes, — methods of learning single things such as dates, and methods of connecting two facts or events that it is desirable to remember together. Systems for remembering single events attempt to connect them with symbols that will be more easily remembered. Numbers are remembered by representing each digit by several consonants and then making words that include these consonants. Thus one may represent 8 by *f*, 7 by *g*, and 1 by *t*. Then one can recall that Alfred came to the throne in 871 if the burned cakes suggest *fagot*, a symbol for 871. Similar combinations could be made to represent any date or number, and the word is easier to remember than the number. Where two events are to be connected in memory, it is possible to form nonsense or superficial connections between them that shall serve to recall one when the other is given. In one system it is suggested that one may remember that *tête* in French means 'head,' by connecting *tête* with 'potato'; that in turn with 'root,' since potatoes are roots, and this by contrast with 'head.' Similar series of words are suggested for many other pairs, and the system consists in forming them for all series of

facts. It is certain, however, that when used extensively, any such system requires more effort and is less satisfactory than the ordinary means of learning. Mnemonic verses and similar devices have some value in remembering a few purely arbitrary facts, such as the number of days in the months, but the usefulness of the system does not extend far.

The best mnemonic system is the ordinary logical system of classification. The connections are not arbitrary here, and each series of associates holds not for one fact alone but for very many. In one sense, the classifications of the sciences are parts of a vast mnemonic system. Each general principle groups many facts about a single statement. Since the general principles are themselves more or less closely connected, they amount in practice to a system of associations in which a few notions, if they are remembered, will serve to recall all the knowledge of the individual. As we have seen, this system of knowledge, when it has been developed, makes easier the learning of all things referred to it, makes their retention more permanent, and by giving them a place assures their recognition. It follows that the more one knows, the better is one's memory; the more one knows of any subject, the easier it is to learn new facts in that subject. Much better, then, than any artificial memory system is a patient, thorough learning, and logical classification of facts. This not only makes easy the learning and retention of the fact in question, but prepares for the acquisition of related facts. Learning logically is like putting money at compound interest. The material is not only saved, but grows and makes easier further acquisition.

Summary. — Memory, then, is not a faculty but a process; and on analysis it is found to be, not one process, but

four that together make possible the reinstatement and use of earlier experiences. Learning, retention, recall, and recognition are special phases of the laws of association, and of the interaction between the particular new events and the earlier accumulated and systematized knowledge. Although the fundamental principles of memory are found in the laws of association, special methods may be used to advantage in learning, retention, and recall. But above all special methods stands the one general principle that memory at each stage requires constant reference to systematized knowledge. This makes learning easy and rapid, gives permanent retention, assures recall on the appropriate occasion, and provides the essential conditions for recognition.

Rules for Learning. — We may summarize the results of this chapter in a series of rules for study both for material to be learned verbatim and for the ordinary retention of ideas.

For rote learning:

1. Read over carefully the material to be learned, slowly at first, then more rapidly as it begins to be mastered.

2. Read always with the intention of remembering as well as with full attention.

3. Attempt to repeat as soon as you are confident of success and continue to repeat actively until the material is thoroughly impressed.

4. Do not attempt to learn all at once. Divide your repetitions. Repeat once a day, or on alternate days until mastered.

5. Read the whole selection through from beginning to end rather than attempt to commit bit by bit. If parts offer especial difficulty, you may well depart from this rule to impress them separately. These should be divided from

the rest by an interval before and after. Reading through the whole once each day will master a selection of considerable length with little effort.

6. Rest for about six minutes after learning one selection before turning to other mental work.

For learning ideas most of the same rules may be applied. In addition:

1. Understand what you read. To this end (*a*) read always with a 'why' in mind; ask is this so and find good reasons for or against before you leave it. (*b*) Where possible refer each fact to its causes. (*c*) Think over what you read in its important connections. (*d*) The relations should be represented graphically in a diagram. In taking lecture notes, write an outline of the main logical heads and fill these in from memory immediately afterwards. Make a similar outline of each chapter of a book as you read.

2. Review as frequently as possible to obtain the value of divided repetitions. In reviewing, diagram again and bring out in this review diagram the relation between the different lectures or lessons.

3. Make as many active responses as you can during the studying. Apply what you learn in as many ways as possible. Work problems that involve the principles. If the material permits draw the objects described.

4. On the rare occasions when facts have no logical connections you may form arbitrary or nonsense associations. These should be used as little as possible and then only when they are obvious and unambiguous.

5. In both forms of learning, trust your memory in recall. The first suggestion is probably correct and should be accepted unless you have positive reasons against it. Confidence aids memory, while doubt paralyzes recall.

IMAGINATION

Definition. — Closely related in many ways to memory are the processes grouped under the term imagination. This term is used in two senses. (1) It designates the process of forming images, the root meaning of the term; (2) it covers all processes of construction, ranging from day dreaming to developing scientific hypotheses. The first use of the term is approximately identical with the formation of imagery discussed in Chapter V and need not be considered again here. The second term covers a wide field of operations closely related to memory and reasoning and in many respects intermediate between them in character. The ideas develop in imagination as in memory under the stimulation of some sensory process and run their course under the influence of associations. As distinguished from memory the products of imagining are not reinstatements of old experiences but are new. This does not mean that the materials are new. As has been repeated frequently, all the central processes are, fundamentally, returned sensory experiences. In imagination, however, the materials are combined in new ways and thus make new objects or events.

The Course of Imagination. — The field of imagination covers many of the most striking functions of human life. The poet and novelist, the artist of all types, are imagining as their constructions develop. Closely related to their work is the attainment of the inventor and the scientist. Since, however, the latter aim at the discovery of truth or the production of an instrument or machine that will really work we may consider their activities under the head of reasoning. When we ask how one can imagine, the only answer that we can give is: have a certain amount of

knowledge and then let the operations go on as they will. The poet has his verse develop more or less spontaneously, frequently when he is trying to do or think of something else. The novelist has his plots present themselves much as the average man's day dreams. Developing them may require careful study, frequent testing and rejection, but the plot itself is likely to come almost out of the blue. Youth is apparently an advantage for great originality, as then the habits and fields of thought have not been fixed. No specific rules can be given.

Control of Imagination through Association. — After the end has been attained and one looks back upon the way the construction has been developed, it can be seen that each link is suggested by the preceding, and that each connection falls within some one of the types of association mentioned above. Knowing these laws will not enable you to write a great novel, however. At the most it would inform you that if you desire a new idea it is well to look to some external stimulus to present it. The associative processes are constantly active, mental pictures occupy the entire waking life, but it is only now and again that the constructions are of value. It is not possible to obtain a particular effect directly. Usually a number of constructions will appear before one presents itself which fulfils the requirements and wins approval. The acceptance or rejection alone can be controlled; what shall appear is subject only to the most general control. That one cannot even think of a new thing at will is made evident by attempting to draw as many different figures as possible. When examined all show many of the same characteristics, — one element runs through them all. While a desire for one idea will nearly always induce something of the same class,

more exact control is impossible, — one can only wait for the desired construction to turn up and it may come soon or late or never.

Forms of Imagination. — The products of imagination may be more or less like objects and events actually experienced. It is customary to distinguish between reproductive and productive imagination. The productive imagination gives material that is very different from anything seen before, reproductive is more like memory. The difference is one of degree only and no great agreement can be obtained as to what is productive and what reproductive. It is said that Sir Walter Scott carefully examined even the minuter flowers in a setting that he had chosen as the scene of one of his romances, thus taking much of what was to be a new construction from direct and detailed observation. This would certainly be reproductive imagination in spite of the newness of the events depicted. At the other extreme are certain descriptions of poetic fancy, Dante's Inferno for example, or the constructions of the mathematician or inventor. One approximates memory, the other reason. They differ in the attitude taken toward the product rather than in the product itself or the way in which it is attained.

QUESTIONS

1. How much of the accuracy of the testimony concerning an accident depends upon attention and perception and how much upon memory?

2. What is the difference in the activities involved in observational and in rote memory?

3. Is learning ever perfect? Is forgetting ever complete? What is the difference between learning half and half learning?

4. What is the 'setting' process in learning? How does it explain the advantages of divided repetitions?

5. What is retroactive inhibition? how dependent upon the perseveration tendency?

6. Why is cramming a bad method of study? Answer in the light of the laws of learning and forgetting.

7. What rules should be observed in studying to make probable a satisfactory recitation?

8. How does the ordinary recitation by question and answer illustrate the laws of recall? What is the question and what the answer in the terminology of memory? Give some conditions that may make a good recitation impossible, even if the answer to the question is known.

9. Cite instances from your own experience of associative and reproductive inhibition.

10. What are some of the advantages of forgetting?

11. Give instances in your own experience that illustrate the advantages of logical over rote memory. In what subjects do you use the first and in which the second?

12. Trace the course of recognition in some instance in which recognition is delayed. Why should the mental operations that result make the object seem familiar?

13. What rules suggest themselves for acquiring a good memory? What are the limitations of the rules?

EXERCISES

1. Show a group of students a picture with a few prominent highly coloured figures. Twenty minutes to an hour later ask the members to describe it in detail. Prepare a list of questions to bring out important points and request them to answer them. Count the number of objects that can be readily seen and find the proportion of these reported by each subject. What percentage of objects reported are not in the picture or are wrongly described? Make a similar count of the questions rightly answered.

2. Select two bits of verse of eight lines each as much alike as possible in meter, ease of learning, etc. Learn one at one sitting, keeping a record of the number of repetitions and the time required for learning. Read the second through twice each day until it is learned. Which method is the more economical?

3. Choose two other selections of eight lines. Learn the first as you naturally would, or two lines at a time. Learn the second by reading through from beginning to end. Compare the two results for the time and number of repetitions required. Unless the selections are well chosen, it may be necessary to repeat the experiment several times and average before positive results are obtained.

4. Relearn after twenty-four hours one of the selections learned for Exercise 3. Relearn another originally learned by the same method after forty-eight hours. Compare the number of repetitions required for relearning each with the number required for the original learning. How can you use the results as a measure of retention or of forgetting?

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CHAPTER X

REASONING

1 period

The Nature of Reasoning. — We hear much of reasoning as the highest of human functions. Man has been defined as the reasoning animal. Learning to reason is one of the ends most frequently mentioned as desirable in education. To reason well is accepted by all as a mark of high ability. Obviously we cannot complete our survey of the intellectual processes in man without examining the character and conditions of reasoning. We may detect reasoning either in the character of the action or in the character of the thought of an individual. Action is rational when it attains its ends immediately and directly, without the numerous false trials that are seen in all of unpracticed activities in animal and in much of human action. Examination of the mental antecedents indicates that in most instances acts that move directly to their end have been prepared in advance in thought, and the acts are but the execution of a previously developed plan. A bridge is built without false moves, because a plan has been carefully worked out by the engineer and given to the workmen who merely put into steel the design given them on paper. The essentials of the reasoning process must then be sought on the mental side.

Reasoning Distinguished from Other Mental Processes. — Reasoning may be distinguished from memory and imagination, not so much by the character of the mental

states or by the way they are obtained, as by the attitude taken toward them when they arise. The idea attained by reasoning may be exactly like an idea which on other occasions is merely remembered. The laws that govern the appearance of rational ideas are the laws of association, controlled in the same way as in memory or imagination. The three processes are different in that the results of reasoning are new and are accepted as true; the results of memory are true, but not new; and the results of imagination are new, but not true. Belief is the acceptance of a construction as true, and may be said to hold the same relation to reasoning that recognition does to memory. When an idea is recognized and believed, it is remembered; when believed, but not recognized, it is the result of reasoning; and when neither recognized nor believed, it is imagined. It should be said that thinking which is intended to give truth but fails in that purpose is still reasoning. One may have false reasoning as well as true. The criterion is the intention. The distinction between memory and reason may be illustrated by the different ways of preparing a lesson in geometry. One student merely commits the demonstrations to memory and, when called upon to recite, repeats by rote the words of the book. Another may read the proposition and work out his own solution. He uses the conclusions reached in earlier work as his basis and follows the model of previous demonstrations. He believes in his result because he can see that it fits in with the other propositions he has learned and with other things that he knows. He may use a method intermediate between memorizing and reasoning. He may read and test each step for himself, and then in the recitation work out the problem in large measure as if it were a new problem.

Objective Criteria of Reasoning. — It is possible to determine from watching the movements alone of man or animal, whether the process is reasoning. Here we must distinguish the reasoned from the habitual or instinctive act, on the one hand, and from mere chance responses, on the other.
N. B. As compared with habit or instinct, reasoned actions must be new, — this must be the first occasion on which the movement has been made: as opposed to mere chance response, the reasoned movement is repeated unfailingly, and is not preceded by other responses. Lloyd Morgan illustrates the difference by the way his dog learned to carry a stick through a picket fence. His habits and instinct led him to pick it up by the middle. Of course it caught at both ends on the pickets. Only after many trials did he happen to hit upon seizing it by the end and thus succeed in dragging it through. If he had reasoned, he would have appreciated the impossibility of his first method without trial, or at the first trial. The trials would have been made in thought only, and action would not have been attempted until the problem had been solved mentally. Then one act would have been all that was necessary. Possibly, one would accept as reasoning an act that gives an adequate solution of a new problem, when no solution in thought preceded the act. On this the definitions divide. If one does include acts of this sort under reasoning, it is possible that animals reason; if reasoning is always a process of first making a plan in thought, then one can never know whether animals do or do not reason.

Reasoning in Practice. — Whether in thought only or in action, reasoning is a process of problem solving. One thinks only when memory on the one hand and habit and instinct on the other do not lead to a satisfactory con-

clusion.) Two great classes of reasoning may be distinguished, invention and explanation. In inventions the problem is a physical one. A man is blocked in his progress either literally or metaphorically. He seeks to find a way out. If it is a physical block he looks for a way over or around the obstruction. If he is walking along a narrow path on a steep cliff and finds that a bowlder has blocked the path, and he must go on, he searches for a ladder, or smaller rocks, upon which he may mount. He must have an aim for going ahead, a purpose, or he would merely turn back. In an invention, similarly, something is to be accomplished mechanically that has previously been done by hand. The reward for the use of machinery is great saving for the user and great profit for the inventor, as when Whitney started to develop his cotton gin. For him thinking of some device that would attain the end — that would catch the seed and pull it from the cotton — was a process of casting about at random among objects he knew, just as the climber on the mountain must cast about with eye and mind for the means of surmounting or circumventing the obstacle.

Reasoning to Provide an Explanation. — Very similar to reasoning as a means of avoiding a physical difficulty, is the process of understanding or explaining which we find in all of our daily thinking and which is one of the incentives to develop the sciences and philosophy. The incentive to reasoning in these cases, too, is some difficulty in applying familiar principles to a given case. The process of solving is again one of trying one idea after another until a solution is reached. Newton is said to have developed his theory of gravitation to meet the difficulty of understanding why an apple should fall down rather than up. Most scientific

advances are made when it is seen that two generally accepted principles are inconsistent, and a broader notion must be found that shall harmonize the two.

General versus Particular Ideas. — One fact that is especially striking in connection with reasoning is that we frequently make use of general notions and general principles, rather than of ideas of single objects or events. We usually work out our inventions and minor devices in the belief that we can apply the solution to many purposes and make the instrument or machine of many different kinds of materials and still have it accomplish its purpose. In the discussion of memory we have seen that we tend to translate particular events and objects into a single general form, and to remember that general statement while the particulars of which it may be composed are forgotten. The nature of these general ideas and the way they are developed offer a problem of importance. We call the general idea a concept. Of the concept we may ask two questions: the structural, as to what it is, and the functional, as to how it can represent the particulars.

Forms of Concept. — We may distinguish two theories of the concept. The first makes it a representative of a class, and assumes that the representation of the class is an idea different from any particular idea of a member of the class. It has been thought at times that concepts of this type in some way develop through a gradual fading out of the particular details of the objects that constitute the class and the retention of the common factors. On this basis one would expect to have a generalized image of each class. In some few cases this may be true. If you will watch yourself as you think general ideas, you will notice that for the most part you represent general notions either by a particular

1. power to produce effects; production of the effect intended.

image or by a word. An idea of man in general may be a picture of some one man. Your notion of force may be represented by nothing more than the word, or by some slight straining of the muscles that might be used in exerting force. Where it exists, the general idea has no efficacy in itself. Its value, like that of the particular idea, lies in its meaning. A concrete image can exert this representative function as well as a general one. The meaning, not the image, is general.

The Nature of Meaning. — The problem of how one image can mean several things must be met before we can go on. Apparently, meaning depends very largely upon the associates that may be aroused by the image. A word may replace in thought any object with which it has been closely connected. After a few repetitions the process may be reversed and the object associated may replace the word. Soon the word comes to be used in place of the object, for one knows that the image would come if desired whenever the word is thought. A class meaning attaches to the word when one knows that not one object alone but several similar objects might appear when the word is used. The word 'dog' may be used no matter what color, size, breed, or sex of dog is intended. After an associate or group of associates has been connected with a word sufficiently often, the word itself is modified for consciousness by the very tendency for them to present themselves or to be aroused. The tendency for the associative paths to open seems to colour the word from which the paths would start. An awareness of what might be aroused anticipates the actual entrance of the ideas. This anticipatory awareness constitutes the meaning of the word. Any idea that has associates has a meaning of the same kind.

Meaning and Recognition. — This is the same phenomenon seen in the last chapter to be involved in much of recognition. (There the new object was given a place in earlier experience by the associates which were on the point of being aroused.) We recognize a face just as well when the images of the place where we last saw it give merely the aura of their presence, as when they actually present themselves. The similarity to recognition extends to the general meaning as well as to the particular. I recognize a bird as a robin, but not as the robin that has its nest in the oak opposite my window; I recognize a tool as a hammer, but not as my hammer. This general recognition is due to the connections that are partially aroused with numerous similar objects and with the name. In the same way a concrete image or word takes on general meaning when it tends to arouse the image of many objects, not of one alone.

The Quality of Meaning. — One can see that an image or word without meaning is different from one that has meaning, although no particular description can be given of the meaning itself. We can be sure of the function but not of any quality. That there is a difference James long ago showed by noting the disappearance of meaning after long fixation of the object. Gaze for a minute or more at a word taken at random on a page. After a time it seems to lose its significance, it seems no more than a ghost of its original. How different it is from the word as you meet it casually, you can see only if you will try the experiment. That the meaning varies with the connections is evident. Few words have one meaning alone. The significance of a word or other image varies with the attitude or the context just as the associates do, and, we may assume, because they do. In an English book 'son' has one meaning, in a French

selection an entirely different one. When we see that ideas are of value for their meanings alone and that the meaning varies with the connections, the problem of the general idea offers no further difficulty. A general idea or concept is merely an idea or image that has been associated with and tends to arouse the images of a large number of different objects. It comes to mean them. It represents them in thought, and we know that it represents them without waiting for each of them to be recalled. N.B.

Concepts Aid Knowledge. — Concepts aid greatly in the acquirement of knowledge. In fact it may be asserted that one could remember very little if one did not have them. We saw that sense memory was much easier than nonsense, and sense memory is merely memory of material that can be referred to concepts. Concepts themselves grow by the organization of experience. They may be said to be ways of using the raw materials in thinking. An attempt to remember each particular object would result in confusion. In practice similar things are grouped and a symbol of the group recalled for each. In organizing, it is also necessary at times to reconstruct our notions of an object to make it harmonize different views we have had of it. In this process we reach notions that are truer than any experience we have had. We saw that we could obtain an adequate notion of the top of a table only in this way. After these correct generalized notions have once developed, we not merely remember them in place of the more special forms, but also substitute them for the real sensations in perception.

The Development of Concepts. — The concepts used in the sciences and in everyday life frequently develop by the taking on of general meaning and application in thought

of relatively simple objects. Numbers seem to-day to be very abstract, but they developed from the use of the fingers to designate how many objects were present. As the word ' digit ' shows, counting was at first always on the fingers. The larger groups, five and ten, are the fingers of one hand and of two, respectively. Still larger numbers are multiples of ten, the largest number that can be counted on the fingers. After the habit of referring objects to the fingers in counting had been developed, the reference became less explicit, and finally all thought of the fingers was lost from the number idea. The number symbols developed and were capable of replacing the finger idea altogether. One may still see some evidence of the fingers in the Roman numerals, but in the Arabic symbols in ordinary use, there is now no evidence of any similarity to the fingers or to anything that at all corresponds to the values that are represented. The numbers gathered many associates, and each new sort of thing counted served to make the concept more general in its application, until the original reference and practically all imagery disappeared in the meaning or idea. One can trace similar stages in the development of any sort of concept. Each of the fundamental ideas of science could probably be traced to some perfectly concrete object or idea that had been applied successively to many objects and so gradually lost all particular meaning. General notions like atom, molecule, ether, and force, have undoubtedly developed in this way. Now they are concepts that have value because they represent a large number of particular experiences.

Knowledge a System of Concepts. — What we have referred to frequently in the chapters on memory and perception as the system of knowledge is merely an organized

framework of these concepts. Concepts develop on a small scale to give an adequate way of representing each single object as in the table top. Then it becomes necessary to appreciate more general aspects, as number or distance, and general notions develop. As the sciences evolve, it is necessary to explain more general interrelations and we have the hypotheses and laws such as the law of conservation of energy, of evolution, and the more particular laws of the sciences. These are united into an organized whole and come to replace the particular experiences in most of our psychological processes. We see them in place of the particular sensations. We remember them in place of, or in confirmation of, the particular images, and in reasoning we refer to them to justify each particular conclusion. Without such a background of organized knowledge most of the special processes we have discussed would be ineffective if not impossible.

The Stages of Reasoning. — We have seen that the reasoning operation is ordinarily some bit of purposive thinking of which the conclusions are capable of proof. Reasoning comes when one has a purpose and is thwarted in that purpose. One has no incentive to accomplishment if one has no purpose, and no new operations are demanded if the old habits are sufficient to effect the purpose. Reasoning presupposes a thwarted purpose as its starting point. Three stages in the reasoning operation may be distinguished. First, the obstacle must be appreciated or understood; second, some plan that will remove the obstacle must be developed; and third, the plan that suggests itself must be proved, must be justified. The obstacle may block the progress, either of thought or action. But if the obstacle be to thought alone, it will probably be an obstacle to action

at some time, and to remove it in thought will make action easier when occasion arises. The first of these steps, the process of understanding the difficulty, is judgment; the second is inference; and the third, proof.

One may illustrate the different parts of the process by any simple problem. Suppose two boys are canoeing, and it is desired to reach a distant place in a limited time. Suddenly the canoe scrapes hard on a rock. A moment later water begins to rise in the bottom. At first it is a question whether there is a leak or whether the water has been shipped. As it increases in amount, it becomes evident that the water comes from a leak. When this is decided upon, one has a judgment, a classification or interpretation of the trouble. Further explanation comes when the scraping on the rock is recalled, and a complete understanding is obtained when the canoe is turned up and the hole through the canvas is discovered. The next step is to decide upon a remedy. Someone suggests that a patch might be made of a handkerchief. This is probably rejected as soon as the thinness of the material is recalled. A second or added suggestion, that the handkerchief be covered with pitch from a spruce tree on the shore, is accepted by both and and put to the test. Thinking of coating the handkerchief with pitch constitutes the inference.

Were the suggestion of using pitch questioned by one, and successfully defended by the other, the process would be completed in proof. Proof comes only when there is preliminary doubt on the part of the man who makes the suggestion, or on the part of someone who hears it. Ordinarily the suggestion will be accepted without question. It will be believed at once and at once be put into practice. It is only when there is doubt before the test is made that

one requires proof, and the full reasoning process is completed. In our case, one would justify the use of pitch on the handkerchief only when someone asks how that would help. Then the justification may be made in one of several ways. One may answer in the abstract that pitch is sticky and waterproof, or one may recall that the Indians used pitch in repairing or making canoes, or one may recall his own use of pitch for some similar purpose.

The Judgment. — Of these steps in the reasoning process, judgment and the different forms of proof have received the most attention, particularly from the logician. The judgment may be defined most simply as the process of referring a new situation to its appropriate concept, or, as it is more usually defined, as the process of 'ascribing meaning to the given.' Each difficulty or obstacle has a different class in which it belongs; it is understood in terms of a typical older experience, or group of older experiences, which usually has been named. When anything is understood, it is referred to a familiar class or object, and this reference, in a sense, tranfers the meaning of the old to the new. Each difficulty or obstacle has a class in which it belongs and, when it is referred to that class, it is in a fair way to be solved or overcome. At least the first step has been taken towards overcoming it. When an army engineer has been assigned the task of bridging a river, he must appreciate and classify the various features of the obstacle. He must measure the width of the stream, the depth of the water and the height of the banks. He must determine the particular dangers to which the place is exposed. Each of these measurements is in essentials a reference of the new problem to a familiar class. When he has judged each of its aspects in this way, he is ready to solve the problem.

He is ready to determine what type of bridge to construct, and can decide what kind and lengths of material to order.

Classes of Judgments. — We may even distinguish different classes of judgments themselves. They themselves may be judged. The simplest is the judgment we have been considering, which we may call the judgment of classification. A second type is the judgment of comparison. This judgment is made when it is necessary to decide between two objects from which one must choose for the accomplishment of any end. Comparison is an immediate process of appraising two objects with reference to which is greater or less in size, weight, beauty, or any other characteristics. It may be said to be like the ordinary judgment in that the particular difference is referred to a typical relation with which we are already familiar. Although comparison involves two objects, it is itself a single process. Decision is made whenever two objects are inspected with the question dominant as to which is longer, heavier, brighter, or what not.

The Judgment of Evaluation. — The third type of judgment, evaluation, is the form most frequently used in everyday life. In this the object to be judged is referred to a scale of values or excellences which an individual has acquired in the course of his experience. We judge all commodities with reference to their monetary value when buying them. We judge people with reference to their intelligence, their morals, their agreeableness, and the probability that they will succeed. All of these judgments are made by assigning the particular specimen to the point in the scale where he or it belongs. The standards are not usually definitely pictured. The one who judges may not even know that he has the standards until called upon to judge.

The procedure prescribed by the army personnel board for grading officers asked the judges to think of five men who represented the best, the worst, the average, and one midway between in each of the qualities to be judged and then to grade the man to be judged by saying which man he most resembles. This made the scale of standards fully conscious. Evaluation probably gave the name judgment to the process, as it is what the judge does in criminal cases. He must first classify the crime and then decide on the severity of the offense in the scale of offenses and assign a punishment accordingly.

The Verbal Judgment. — When the appreciation of the situation is expressed in words, the new element to be understood is put first and so constitutes the subject of the sentence, while the concept to which the new is referred is the predicate. Sometimes the situation is left undesignated. In that case the subject is omitted or made indefinite. When the water is seen to appear in the bottom of the canoe one boy may call 'there is a leak.' In this the 'there' indicates direction or merely designates the situation, while the 'leak' gives the interpretation and sounds the warning. In such general remarks as 'it is raining' or 'it is cold' we have the mere designation with no meaning attaching to the 'it.' In the usual subject-predicate form of sentence, as 'that man is tall,' the subject indicates one reference, the predicate another. Usually in that case the subject is more or less taken for granted or represents the result of a classification that has been made in the previous observation. The object is first recognized as a man and then his height, the characteristic important at the moment, is mentioned. Language is very largely a process of translating these interpretations of situations into words, either

for the benefit of the companion, or to facilitate recall by the observer.

Inference. — When the situation has been understood, the thinker is prepared for the active process, finding a solution. This we know as inference. Two parts are to be distinguished in connection with inference: the process of obtaining suggestions as to ways of avoiding the obstacle and secondly deciding which of the suggestions are likely to be effective. The first is very much like the process by which animals find a way of opening a door, or the path through a maze, by trying every movement possible and retaining and repeating those that prove satisfactory. If one is trying to solve a mechanical puzzle, Ruger showed that one may actually make movements towards or about the spot, that seem promising, in exactly the same way as the animal does. If one first devises a plan in thought, the process is very much the same, except that the trials consist in having one idea after another present itself until one comes that seems satisfactory. The ideas are controlled by the laws of association discussed so frequently. No rules for inference can be given except to keep yourself alert, and at the same time cool. Some minds are very much more fertile in solution than others. Knowledge of the subject or of connected subjects gives a stock of ideas that may be applied. The right idea may come at an unexpected moment. It may be suggested by a chance observation in another connection. It is nearly always in the nature of an accident. Watch yourself as you try to solve an original problem in mathematics, or as you plan an amateur radio set, or think of ways to earn money for a vacation, and you will see that you always have many different ideas before one comes that you regard as satisfactory.

Belief the Test of Truth. — The acceptance or rejection of the suggestions is ordinarily immediate. It is the result of an operation very much like recognition. As soon as one has the suggestion, it is stamped as either right or wrong or doubtful. Belief, or the acceptance of a suggestion, arises when it seems adequate as tested by all that we know of the problem. When it harmonizes with all that we know, it is accepted. As in recognition, the experience that leads to the acceptance or rejection may not be explicit at the moment. It may be latent and reveal its effect only in the belief. When we doubt, there is usually an alternation of settings or points of view, one of which favors and the other opposes the acceptance of the suggestion. As long as this alternation goes on, there is unrest accompanied often by bodily strain. When the alternation disappears in definite acceptance of one or in definite rejection of all, we have belief. When belief is not complete, but a suggestion seems likely, we may turn to proof, the more explicit test. It should be emphasized that proof is not always resorted to. In simpler problems and those that involve only one's self, belief alone suffices. Only when the matter is important and complicated, or where another person is involved do we resort to proof.

Proof. — The process that has most concerned the logician is proof. In fact it may be asserted that the logician has lost sight of the other active parts of reasoning in the importance that he assigns to proof. Psychologically, we regard proof as a process of producing belief in the mind of the hearer, or of confirming belief on the part of the thinker. Essentially proof may be regarded as a process of making explicit the knowledge that is implicit in belief, and in showing how it is related to the conclusion. The forms of proof

are ordinarily divided into deductive and inductive. Deductive proof gives belief by referring the conclusion in doubt to some general principle or law already accepted. The new receives added credence from the old. Induction draws the justification for the conclusion from specific earlier experiences or from experiment.

The Syllogism. — The most familiar form of deduction is the syllogism. In the syllogism, the general principle by which the conclusion is justified is ordinarily stated first; then the conclusion is referred to that general principle; and, finally, the conclusion to be established is stated. It may be illustrated in 'All metals conduct electricity: tungsten is a metal, therefore tungsten conducts electricity.' It should be asserted explicitly that the order of thinking is not the order of the syllogism, but that the conclusion presents itself first, and the rest of the syllogism is then developed to justify the conclusion. One would never make a series of statements of the sort, unless one had started to use tungsten to close an electric circuit and someone had questioned its value. The syllogism in practice is advanced to prove the conclusion, and develops after the conclusion has been hit upon and questioned; the conclusion does not grow out of the major premise. In actual everyday thinking the syllogism seldom makes its appearance. The conclusions are nearly always rejected or accepted immediately, and no justification is required. When it does appear, it is usually expressed in a much abbreviated form. In the example given, one would say merely, 'tungsten is a metal, you know'; and this would suffice to suggest all that is important in the syllogism.

One question that might be raised is, why does the syllogism or the mention of the major premise constitute proof?

The answer is that it serves to connect the conclusion with the system of concepts or general principles previously accepted. When one sees that the new suggestion comes under the old principles, the belief that has been developed for that principle extends to the particular instance. When established and accepted laws and principles are connected with the conclusion, doubt disappears. The process of reference to the system of knowledge not merely justifies the old, but also increases the number of applications of the old. Each doubt that is resolved increases the belief in the principle, since it assures its connection with a new fact. It extends its application, and when the conclusion itself is confirmed in practice, the general principle receives new warrant.

Proof by Induction. — The second form of proof, induction, consists in reference of the suggestion to the particular earlier experiences. When questioned about tungsten, one would not reply that it is a metal, but would point to an electric lamp, or recall some other instance in which it is known that tungsten wire has been used in electrical work. Or one might take the still more empirical course of actually testing to see whether it does conduct, and whether the resistance is low enough to make it useful in the particular application. It is probable that the proof from induction is much more closely related to the proof by deduction than was assumed of old. The particular instances, by which the conclusion is justified, must be in some degree typical or they will be valueless. If the tungsten used before was mixed with some other metal, it might very well be that the results that held of that sample would not hold here. Unless again it is assumed that laws hold universally, no conclusion can be drawn from any number of particular

cases. Each new case would needs be studied for itself and the results of one experience could not be applied to a later case. Again, as has been seen, older developed concepts are involved in any perception, so that, in each of the particular observations, principles, similar in kind to the general principles that warrant the conclusion in the syllogism, must have been used. On the other hand, there is always more or less implicit reference to particular experiences in the general principles that justify the conclusion in the syllogism. The difference between the two sorts of proof is one of emphasis only; the same fundamental principles are involved in each. In any case proof is found in a reference to experience. In one case the experience is formulated in concepts and the general is emphasized; in the other the particular experiences are in the foreground, the general laws only implied.

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Analogy. — Perhaps the form of proof most used in popular discussions is analogy. It involves something of the principles of each of the more formal types, induction and deduction. Analogy consists in pointing out the similarities between the statement to be proved and others with which the man to be convinced is familiar and which he is willing to accept. Thus, one argues that a man should invest in a new company by mentioning companies in the same line that have succeeded. One argues that it is possible to communicate thought without words, written or spoken, by mentioning the radio. Analogy is a satisfactory form of proof, provided only that the similarity is in essentials. Too often the resemblances are in non-essentials and the proof is seeming, not real. Thus the argument for the new stock is likely to say nothing of the relative financial standing of the two companies and

attempts no comparison of the probable earnings. The argument for telepathy or thought transference without words neglects to mention the lack of transmitting or receiving apparatus. Where analogies are critically drawn, they approximate the validity of the syllogism; where the resemblances are only superficial, they may be completely misleading.

Note

Summary. — In brief outline, reasoning consists in solving problems, and in justifying the solution when it is obtained. The occasion for the reasoning is always a thwarted purpose. The first step in the solution is to understand the nature of the check, and this is accomplished by referring the present difficulty to some old principle, to some old concept. The second step is to obtain a solution. This is provided by the laws of association. Finally, this solution must be justified when questioned. The justification is, ordinarily, through reference of the suggested solution to the system of earlier knowledge, to the system of concepts. The whole process of inference is thus a series of interactions between the new and the old and ordered experiences. The old is constantly giving order and warrant to the new, while on their side the new are constantly extending and correcting the old experiences.

QUESTIONS

1. How may reasoning, memory, and imagination be distinguished? Habit and reasoning?

2. What gives an image meaning? What makes an idea a concept?

3. How does your abstract idea of a triangle differ from your memory of a particular triangle? How do you picture to yourself 'machine' as a general term? Describe the mental content fully.

4. Can you trace in your own experience, or in the experience of some child you know, the growth and extension of meaning that a concept like force has undergone?

5. Enumerate five abstract terms in English which bear evidence of the development of the corresponding concept from a concrete experience.

6. How is a science a system of concepts? How does such a system develop?

7. Outline the steps in a reasoning operation.

8. Illustrate the three more important forms of judgment: of things; of relations; of values.

9. What do you mean when you say that you understand a mechanical toy? What does seeing your way out of an involved situation imply? How is the process related to judgment as it is defined in the text?

10. How is inference related to action? What place has association in inference?

11. When do we prove a conclusion? How do you prove any conclusion or statement?

12. Distinguish inductive from deductive proof. How are they related?

13. How do you know when the solution of a problem is correct? How can you demonstrate its correctness to another?

EXERCISES

1. Stare at the word triangle for a minute by measurement and keep a record of the changes the word goes through during that time. Explain the result.

2. Prepare two weights of 10 and $10\frac{1}{4}$ grams by loading empty cartridge shells with shot. Have an assistant lift first one and then another and judge which is heavier. What is the process? Does a type play any part?

3. Try to work out an original device of a simple sort; *e.g.* find a substitute for a stairway in your dwelling. Record each step in the mental operation. Designate the process in a single word.

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CHAPTER XI

FEELING

Feeling and Behaviour. — As was said in discussing instinct, we find that both men and animals react to all objects in two specifically different ways. One group causes movements of withdrawal if in contact; on occasion they produce violent excess movements as long as they are applied to the sense-organs; when taken into the mouth they are at once rejected. The other produces a relaxation of the body, the cessation of movements, movements of approach if the object be at a distance, swallowing if the substance has been taken into the mouth. These two opposed groups of reaction are of primary importance in the experience of the race and of the individual. Responses of the first type spur to new acts that may remove the stimulus. In so far they are incentives to the development of new types of responses, and so to learning. The other group, known popularly as pleasant, tends to encourage the repetition of movements and so select from the movements made by chance those that shall be repeated and established as habits. We say in the rough that one group is preferred to the other, that one produces dissatisfaction; the other satisfaction. Whatever we call them it is obvious that the opposed reactions are the most important forces in determining the adjustments of the individual to the environment. The nature of the response depends upon the sense-organ affected as well as upon the object. A sticky sweet

in the mouth may produce swallowing, while on the fingers it brings about vigorous attempts to get rid of it.

Like all of the other facts of behaviour, this selection or seeming preference may be approached from two sides. From the outside it has been described above as a process of approach or quiescence if in contact with the object, or of violent excess movements and of lack of movement. On the conscious side the one is accompanied by pleasure, the other by displeasure. As a conscious process the difference between pleasure and displeasure seems to parallel many of the most important distinctions in our lives. The movements that are learned, objects that are sought, ideals that are accepted, all are pleasant, — whether the pleasure be cause or accompaniment we need not at present consider. If we treat pleasure and its opposite as causes or concomitants of causes, they would be, like attention, important agents in determining the course of consciousness and of action.

In discussing habit formation it was said that the movements which produced pleasant results tended to be repeated, while the movements that brought unpleasant or even indifferent results were later avoided. In explaining instinct one has at times resorted to the pleasure that accompanies movement as an explanation of the act. Here we are tempted to seek an explanation of pleasure in terms of instinct or of repetition of the movement. There we should have liked to say we learned because we were pleased; here the tendency is to say we are pleased because we move or learn. The relation of feeling to thought and idea is not so direct. One may seek pleasant ideas but is not always able to exclude the unpleasant, and both pleasant and unpleasant stimuli affect consciousness more readily

than indifferent ones of the same intensity. Obviously, pleasantness and unpleasantness require careful treatment. Before we attempt to investigate their influence upon behaviour, we may describe them as conscious processes and assign them their places among other mental states.

Uses of the Term. — The term feeling is used in many different senses. It is made to cover all sorts of mental states, from tactual sensations to the vague intellectual appreciations of truth. We 'feel' with our fingers, and we 'feel' that certain things are true when we are unable to prove them by any formal methods. Feeling indicates at different times and for different people all the vague experiences. The sensations from the skin are regarded as less definite and precise than those from sight and hearing. In the other fields the same use is predominant. The organic sensations are popularly classed as feelings, as are the psychological processes, like recognition and belief, which have not been definitely analyzed.

Obviously it is not possible to discuss all of these different states in one chapter or in one connection. As used, feeling stands for the unclassified in every field. Wherever we have been able to group facts about certain typical phenomena, there are other similar facts that seem to belong in the same group, but which cannot be definitely ascribed to that class. These constitute the feelings in the broader sense. Because they have not yet been reduced to types or forms, they cannot be described or defined. They are the limiting terms of our science. Whenever they cease to be indescribable and take on definite form, they cease to be feelings. Evidently, feeling in this broader sense is something that cannot be discussed; when it is possible to discuss it, it is no longer feeling. Another objection to treating

feeling in this sense is that there would be, on this definition, as many different sorts of feeling as there are different classes of experience. The feeling of belief is no more like the feeling of discomfort from bodily illness than the sensation of contraction is like a syllogism; the feeling of recognition no more like a feeling of moral virtue than a memory image is like a voluntary act. If one were to attempt a discussion of feelings in this sense, a separate treatment of each would be necessary, and it would be most convenient to discuss them in connection with the experiences of the same group that already have been analyzed and reduced to laws.

Feeling as Pleasantness and Unpleasantness. — Pleasantness and unpleasantness are the only definite mental states to which the term feeling is applied. A description of them is as difficult as of any simple process, but there is no doubt what is meant when the word pleasantness or unpleasantness is used. Pleasantness and unpleasantness are general and are found in connection with practically every other state. They may be induced by impressions from any sense, and by memories of many different qualities. They are found as the accompaniments of different actions, in fact are attached to all sorts and conditions of mental processes. Pleasantness and unpleasantness are really distinct mental qualities and deserve a special name, whatever it may be. Psychologists are agreed in calling these two qualities feelings, no matter what others they may add to the list. We can decide arbitrarily to regard pleasantness and unpleasantness as the feeling qualities and omit the others, not because they are unimportant in themselves, but because they are not feelings on the same level. So far as a discussion of them is possible, it is

carried on to better advantage in connection with other subjects.

Differences between Feeling and Sensation. — Even if we grant that pleasantness and unpleasantness are peculiar states of consciousness, the question is raised whether they are distinct sensations. Ordinarily feelings arise through excitation by some stimulus and are closely connected in origin with sensations. But we may have both feelings and sensations from the same stimulus at the same time and can always distinguish them. The two are never confused. Many formal arguments have been devised to show that they are really different sorts of mental content. Perhaps the most striking is the general dependence of the feeling upon the individual and his peculiar experiences. When the same stimuli affect us, we see approximately the same things, but we feel very differently at different times. What pleases at one time may displease at another. What one feels depends upon the individual and his mood at the moment, as opposed to the nature of the external stimulus which determines the nature of sensation. Feeling is as much subjective as attention, while sensation is more dependent upon the physical environment. It is in this sense that feelings are subjective, sensations objective. Coupled with this subjective character is the further fact that an experience when recalled does not always have the same feeling as at first. What pleased at one time as a boyish prank may cause mortification in maturer years. In the same way an early social blunder that occasioned keen chagrin at the time may now excite nothing but mild amusement. The individual has changed in the meantime and the feelings change with him. That feelings undergo change between the actual experience and the recall has led

N. B.

lacks definiteness or conceptual character

to the statement that we cannot remember them. It is true that we cannot recall the pleasantness in all of its warmth, but we do recall the sensational elements and receive the same feeling as if they were experienced at present. We undoubtedly remember that we were pleased or displeased, or there would be no question about the change in feeling. The remembrance is in words or other conceptual terms.

This subjectivity or dependence upon the nature of the individual and his momentary mood is the most striking characteristic of feeling. Closely related to it is its lack of anything that partakes of definiteness or of a conceptual character. Feelings seem to vanish when one attempts to describe them or even to attend to them. Any attempt to analyze the characteristics of pleasure brings about a diminution if not the disappearance of the pleasure. Even to ask whether one is really pleased or not has much the same effect in smaller degree. Pleasure vanishes when examined carefully. The mood of analysis is not conducive to pleasure and in less degree is not conducive to displeasure. These general characteristics of the feelings seem sufficient to mark them as distinct mental qualities. Pleasantness and unpleasantness must be regarded as belonging in a different class from sensations.

The Quality of Feeling. — Feeling is much less rich in qualities than sensation. The qualities upon which there is general agreement are pleasure and displeasure, or pleasantness and unpleasantness. They are both opposed to indifference. Indifference by some authors has been made a distinct class in addition to pleasure and displeasure. Indifference, however, is probably merely the lack of feeling and is applied only to the stimulus or to sensation. An

indifferent stimulus is one that does not give rise to feeling; Note there are no indifferent feelings. There are but two qualities of feeling, although stimuli that arouse feelings may be opposed to indifferent stimuli or sensations. The intermediate position is more suggestive, if we consider the degrees of pleasantness and unpleasantness and their relation to the intensity of the stimulus. Pleasure and its opposite vary in degrees in both directions, from just appreciable to very intense feelings. Wundt early suggested that there was a constant relation between the intensity of the stimulus and the nature and degree of the feeling. Faint stimuli are ordinarily either indifferent or mildly unpleasant. As a stimulus increases in intensity, it becomes more and more pleasant until it reaches a maximum. From then on its pleasantness decreases to positive disagreeableness. Slightly sweet substances are indifferent or disagreeable. As the degree of sweetness increases, the substance becomes pleasant, while the intense sweet of saccharine is unpleasant. This relation holds approximately for some senses but it cannot be regarded as a general law.

Feeling and Affection.—It has often been asserted that there must be different feelings for each sense department, and even for each sense quality. This depends upon the Note fact that one does not distinguish between the feeling proper and the accompanying sensations. The sensations in the complexes are different and make the whole complex different. The feeling proper is not discriminated from the sensational colouring. The elementary feeling process is often confused with the complex, even in psychological writing and thinking. To avoid the confusion it has become usual to apply the term 'affect' to the mere pleasantness and unpleasantness apart from the sensational com-

affect – feeling apart from sensation

feeling = complex (affect + sensation)

ponents, and to keep the word 'feeling' for the complex. For example, in a toothache we can distinguish the sensation pain from the mere disagreeableness of the pain. It is this disagreeableness that we call the unpleasant 'affect.' Accepting this usage, we may assert that all affects are of two kinds, pleasant and unpleasant, and that all differences in feelings are due to the different concomitant sensations. The difference between a toothache and a headache lies in the localization of the pain sensations, and perhaps in some of the accompanying organic sensations.

Sensation of Pain and Unpleasantness. — Particularly close is the relation between the affect, unpleasant, and the sensation, pain, which is nearly always unpleasant. The affection and the sensation are combined so often in a single feeling that frequently they are not distinguished at all. A few years ago it was usual to confuse the two and speak of feelings of pain as well as of feelings of unpleasantness. Since pain organs have been recognized, this usage is not to be favoured unless the term pain is used in two senses, — to designate both the affection and the sensation. Pain sensations may be pleasant, as in the pain excited by the biting cold of a clear day when one is in good health. The displeasure caused by a sudden pain is altogether distinct from the pain itself, although they are fused into a single complex. The quality of unpleasantness, apart from its setting, is the same in each case. We may conclude that there are but two qualities of affection and that differences in feeling come from the sensational elements in the complex, not from the affective components. N.B.

Sensory and Intellectual Feelings. — Other suggested distinctions are between higher and lower, or sensory and intellectual feelings. In general the two classes overlap.

Intellectual feelings on the whole are supposed to be higher; the sensory, lower. The difference between the intellectual and the sensory is very much the same as that between the different sorts of sensory feelings discussed in the preceding paragraph. In the intellectual, the cognitive components are largely memory processes and products of imagination. Mental accomplishments of all kinds give rise to pleasure; defeat or failure to perform a mental operation resolved upon causes displeasure. The resulting pleasure or displeasure is the same in each instance; the difference is in the occasion alone, the non-effective accompaniments of the pleasure. Between the higher and lower pleasures the distinction is largely in terms of ethical or social values, rather than in the quality of the affect. The higher pleasures are those that are important for the welfare of society and correspond to activities not deeply ingrained by instinct. Society has given an indorsement to the pleasures of the one class because of their benefit to the social whole, while the pleasures of sense are regarded as strong enough to take care of themselves. The pleasure from a good dinner is apparently no different in its quality from the consciousness of a good deed, but the pleasure attaching to a good dinner is sufficiently vivid and the instinct to eat sufficiently strong to need no bolstering from society, while the instinct to perform a good deed is so weak that social approval is necessary to insure its performance. Society therefore expresses its approval by classifying the one pleasure as higher, while its disapproval of the other is expressed by classifying it as lower. Neither of these classifications has reference to the affective quality, and so makes necessary no change in our earlier statement that affections have but two qualities, pleasure and displeasure.

Bodily Accompaniments of Feelings. — The bodily accompaniments of feelings have been made much of in psychological descriptions and discussions. Many bodily signs of pleasure are apparent to the casual observer. When one is pleased, the face is flushed due to the enlarged capillaries, the eye is bright from the dilation of the pupil and the slight secretion of tears, the carriage is erect. In displeasure the opposed responses are seen. Attempts have been made to determine accurately the different component physiological changes that give rise to the psychical condition, but at present the results are conflicting. No exact opposition can be shown between pleasure and pain in the accompanying heart rate, in the size of the capillaries, or in the strength or rate of breathing. All of these processes undergo change in any sort of feeling, but one cannot connect the nature of the change with the quality of feeling. All that can be said is that the changes are more marked in displeasure than in pleasure. The belief of the earlier investigators that they had discovered a definite relation between the bodily responses and pleasure and displeasure does not harmonize with the results of recent investigations.

Theories of Feeling. — Three theories have value as an explanation of the nature and origin of feeling or of the affective component of the feeling. These are: (1) the evolutionary theory which is oldest and probably fundamental for the other two; (2) the theory that relates feeling to association and attention; and (3) the theory of smooth-running and checked mental operations. Each has its place and must be considered separately. The first asserts that pleasure is the accompaniment of stimuli that have in the long run proved beneficial to the race; displeasure, the

evol. theory

accompaniment of stimuli that on the whole have proved injurious. We like foods, we dislike substances that are unfit for food. There are obviously many exceptions to this rule, but they arise largely from the fact that man has evolved, not to meet each specific case, but to meet the general conditions. Thus sugar of lead might be mistaken for cane sugar and be considered pleasant, but to avoid all sweets would be more injurious to the race than to eat all and have the few die who chance upon the poisonous sweets. Similarly medicines are proverbially unpleasant, but man was not evolved to take medicine. They are of value only in exceptional conditions. On this theory, man's action has been adjusted to the environment, and, as a part of the process, there has been developed a conscious foreshadowing of the effect of certain substances upon him. note The promise of benefit from a stimulus constitutes its pleasantness; the warning of injury its unpleasantness. The feelings come in advance of specific experience. They are of value in planning action. In many instances the idea arouses pleasure before the action is begun, or even before the stimulus is received. If the anticipation of the results of an act is pleasant, it is executed, if unpleasant it is inhibited. Metaphorically, one may regard the feelings as organic memories of the effect of stimuli upon the race as a whole, come to light in the individual as a member of the race. As a matter of actual fact, all that this can mean literally is that all individuals who withdrew from beneficial stimuli or approached injurious stimuli have been eliminated. Since pleasure foreshadows approach and unpleasantness withdrawal, only those for whom the affects are suitably adjusted have survived. Evolution and elimination have resulted in a relation between feeling and probable

benefit or injury, that makes the feeling an adequate indication of the probable outcome of action.

The Experience Theory of Feeling. — The first of the psychological theories of feeling seeks to explain the changes that feelings undergo as the individual grows. One of the most striking phenomena in connection with feelings is that they change their character with the experience of the individual. An unfortunate experience with a particular dish may make it unpleasant long after the experience itself has passed out of mind. Some pleasures, too, are the direct expression of association. A national anthem arouses a pleasure in the patriotic citizen entirely incommensurate with the artistic value of the music. Wundt carries the theory a step farther and relates feeling to the activities at the basis of attention. The accumulated experiences largely determine the character of attention. The character of feeling depends upon the experiences of the individual. These two statements may be combined in the theory that feeling is the outcome of attention. The ultimate quality of the feeling as pleasant or unpleasant must still be explained by the evolutionary theory. There is nothing involved in attending to a pleasant object that is not also involved in attending to an unpleasant one. Accumulated experience only serves to transfer the pleasure and displeasure, derived originally from one experience, to others with which they were not at first connected. The pleasure of a song may be due originally to the social instincts that have their source in the community of spirit with fellow-members of the group. Later the pleasure returns when the song is heard. All goes back to the appreciation of benefit and injury, but appreciation is rendered more certain and accurate by the later experiences.

Note. The evolutionary quality or character is extended from the immediately pleasant stimuli to other and related stimuli and qualities of sensation.

The 'Empathy' Theory. — A modification of the experience theory has been made much of by Lipps, who suggested that we all tend to feel ourselves into external objects of all sorts and then enjoy or are displeased by the result. He calls the process empathy. We enjoy the flight of the bird or airplane because we think of ourselves as soaring and have the sense of pleasure that would come with it. An over-slender column under a massive roof displeases because we put ourselves in its place and have the strains that would arise were we trying to support a too heavy load. A massive mountain thrills us because of the sense of power that comes from identifying ourselves with it and standing superior to all of its surroundings. A similar interpretation is given of the beauty of each element in a landscape or a work of art. It assumes that we know directly the pleasures that come from each position and attitude of our body and that all that is beautiful or ugly contains something that leads us to put ourselves in its place and have the feelings that would be induced in us were the substitution realized.

The Furtherance-Hindrance Theory. — The third theory is favoured by Stout and Dewey in slightly different forms. It makes pleasure the accompaniment of any smooth-running, uninterrupted activity; displeasure, of thwarting and interruption. If one's heart is set upon the accomplishment of any task and the task is interrupted in its performance, displeasure is the result. Whatever furthers the progress of the task gives pleasure. What the task is matters not. It is as truly pleasant to progress toward the

solution of a problem in mathematics, when that is the aim of the moment, as it is toward the acquisition of an automobile or the worldly wealth which that signifies. There is undoubtedly a very close relation between pleasure and progress toward a desired end. The possibilities of pleasure are dependent largely upon desires. This theory applies immediately, however, only to relatively active processes or operations. The application is extended by the use of many similes. The more general asserts that there are many more movements than one ordinarily assumes, that movements are called out in relatively obscure muscles and organs that one would never suspect to play any part in the operation.

Modification of Theories in Terms of Instinct. — We may connect the group of facts that suggested the different theories in connection with our discussion of instinct. Stimuli that are unpleasant produce from the beginning violent aimless reactions, while stimuli that we call pleasant induce the cessation of these diffuse movements once they have started, or evoke slight, well coördinated movements. These we may regard as the primary native differences in the reaction of the organism to the two groups of stimuli. There is an indication of furtherance of activity in the pleasant, of inhibition or interference in the effects of the unpleasant processes. This does not altogether satisfy the conditions, for quiescence as well as furtherance is pleasant, and the unpleasant may produce paralysis as well as the hindrance of diffuse movements.

The associatory theory would account for the transfers by what is called conditioning, from one object to another frequently connected with it. All again imply the development in the race of the fundamentally opposed types of

responses by the survival of the fit, which would connect with the evolutionary theory. Our theory of affects then would be that pleasure is the accompaniment of bodily responses that proceed directly to a goal, or of quiescence. Unpleasantness, on the contrary, is the accompaniment of diffused mutually interfering motor discharges, or of an immobility resulting from contractions. Both are accompanied by widespread discharges to the sympathetic system and so to internal muscles and ductless glands. A large part of the qualities of the two feelings is to be ascribed to these opposed internal and external responses. We cannot think of feelings as causing action or in themselves of establishing one tendency to response rather than another. It is the accompaniment of innate responses that have these effects.

QUESTIONS

1. Distinguish feeling from affection. What is the popular, what the psychological meaning of each word?

2. Find cases which prove or disprove the statements (*a*) that sensations are objective, affection, subjective; (*b*) that sensations are clearer with attention, affection less prominent; (*c*) that sensations have a definite sense-organ, affections have not.

3. How can you remember an affection?

4. What are the qualities of affection? of feeling?

5. Can you give pleasantness or unpleasantness a definite bodily seat as you examine any simple experience?

6. What is the real distinction between higher and lower feelings? Is it in the qualities of the affection?

7. Is the pleasure recalled in Question 2 instinctive, the result of training or experience, or an expression of furthered or successful activity? Recall different pleasures that can be explained by each of the theories.

8. Give instances in which pleasure has not been a satisfactory guide to conduct. How do you explain it?

EXERCISES

1. Sometime, when much pleased at some happening, turn around upon yourself and try to analyze the state into its elements. Can you distinguish the 'affective' elements in the total state from the sensational components? Does the pleasure disappear during the analysis?

2. Try to recall some pleasure of last week. Do you reinstate the pleasure or remember that you were pleased? In your opinion is the pleasure as intense as in the original experience? Do you recall the pleasure in its vividness, or merely the sensations that were connected with the experience?

3. Make a list of twenty events in your past that were strongly pleasant or unpleasant at the time. What is your present reaction to each? Is there any law as to change in tone?

4. Watch the pupil of an assistant as you stimulate first with pleasant then with unpleasant odours. Record direction of change in size.

Count the number of breaths for a minute, first under pleasant, then under unpleasant odours. Is there a difference? Record any checking or quickening of respiration after stimulus is given.

5. Prepare a series of crosses with an upright an inch long and cross-bars three-fifths of an inch long. Place the cross-bar on one one-tenth of an inch from the top, the others each a tenth of an inch farther down. Ask ten or more individuals to arrange them in order of pleasantness. Which is most often preferred? Can you explain the choice by any of the theories of feeling?

REFERENCES

ANGELL: Psychology, chs. xii, xiv.
CARR: Psychology, ch. xiii.
TITCHENER: Psychology of Feeling and Attention.

Ind. 8th 1 period

CHAPTER XII

EMOTION

The Nature of Emotion. — One of the most vivid phases of human behaviour and the most impressive of the subjective experiences is presented in the emotions. Objectively it is closely related to instinct, for it is characterized by a widespread group of bodily responses that appear with little or no training or practice. Subjectively it is related to feeling, since all emotions, or nearly all, are either pleasant or unpleasant. Strangely enough while all admit bodily responses in emotion and all who recognize consciousness at all regard emotion as the most striking of the mental processes, there is relatively little agreement as to exactly what movements are involved in the whole. Objectively no specific group of movements is ascribed to love or hate, fear or anger; from the subjective side we have statements that at the extremes there are common elements in love and hate and even in fear. Experiments, too, show that there are the same bodily responses in each. Again no special function can be assigned to the emotions as movements, if we except the relatively slight effect of increasing the vigour of response of the muscles during emotions of all kinds. But the man who approaches the problem from the side of mental states is inclined to see in movements the determining element in all the emotions.

Instinct and Emotion. — As compared with instinct the movements in emotion have no objective end. They

accomplish nothing in the outside world. They are entirely limited to the body itself. Yet they are largely unlearned. Aside, possibly, from facial expression, there is no object in changing them, and these are for the most part altered only by repression. The motor aspects of emotion belong in the same class with the instincts. So true is this, that the emotion has been defined by Dewey and MacDougall as the conscious side of instinct. For instance, fear is instinctive, but fear is also an emotion. Instinct is the process viewed from the outside, emotion is the same process viewed from within. Every emotion has its instinctive side, every instinct its emotional side. Emotion is concerned primarily with the responses that end altogether within the body; impulses are the instincts that lead to action which is directed beyond the body, and these will be discussed in the next chapter.

Ancient Theories of Emotion. — The ancients always spoke of the emotions as having their seat in the viscera. Courage was in the heart, jealousy in the liver, and several of the other emotions had their seat in the abdominal region. *interna organs* Study of an emotion, whether during immediate experience or when recalled, shows that many of its components are sensations from the various parts of the body. In sorrow there is pressure about the heart, in joy a feeling of lightness in the chest. The lump in the throat, the dryness of the membranes of the mouth, all contribute some part to the total emotion. Organic sensations constitute a large part of what can be described or remembered of the emotions. These have a definite bodily seat in the chest and abdomen, and seem to be more or less closely related to the vital organs. This fact explains why the ancients ascribed the emotions to these organs.

James-Lange Theory. — The recent discussions follow the same general tendency. The modern theory which serves as the point of departure for all others was developed independently by James and Lange. This theory makes emotion the subjective accompaniment and the natural outcome of instinct. When a stimulus affects one, it calls out numerous responses because of the inherited paths of discharge. These are the occasion, both for the bodily attitudes as they are presented to the outside observer, and for the consciousness of the emotion as it is revealed to the man himself. Professor James insists that ordinarily there is no awareness of the emotion until the action has been completed. For instance, he asserts that as a small boy he was playing with blood without knowing what it was. Suddenly he fainted. Nothing in the experience suggested the act or gave any indication that he was about to faint. He generalizes this fact in the assertion that the consciousness of the emotion always attaches to the act after it has been completed. The act comes instinctively as part of the stimulus; no thought intervenes, no elaborate working over of the material is possible before the responses which are the expression and wake the emotion as mental state.

Emotion as Instinctive Response. — The theory of emotion in terms of the instinctive response is very generally accepted. There can be no doubt that most of the vividness and life of the emotion depends upon the bodily expression. One is not really afraid unless one feels the general quaking and motor insufficiency, together with the sinking feelings about the heart. One is not really angry unless one is going hot and cold and has lost control of the muscles to some degree. A man who could face a crisis and know it to be a crisis with none of these organic responses

1. insensibility.
11. Of or secreting phlegm.

would not really feel an emotion, no matter how complete the intellectual appreciation he had of the seriousness of the situation. The emotions take their colour from the bodily reverberation, from the sensations that arise from contracting muscles. These contractions are aroused by the instinctive connections between the stimulus and the muscles. Up to this point the character of the emotions is determined instinctively. That the emotions would not have the qualities they do have without these instinctive responses is demonstrated by the observations of the pathologists, that when an individual has widespread anæsthesia of the body muscles, no emotions are felt or at best the emotions are not of the same character as in the normal individual. The deep-seated motor response is an integral part of the emotion; (the emotion disappears or takes on an entirely different character when that response is lacking.)

FIG. 39.—The adrenal gland and the kidney. (*r*) kidney; (*s*) adrenal gland.

Ductless Glands in Emotion. — Especial importance has been attached to the action of the ductless glands in emotion since recent discoveries of their function. The most important for their psychological effect are the thyroid, the pituitary body, and the adrenal glands. All are alike in that they secrete a substance directly into the blood which acts upon the brain, the muscles, and upon general bodily growth and nutrition. As regulators of the body mechanisms they have a profound influence, and they affect the

mental life in many ways. Most important for their effect upon the immediate emotions are the adrenal glands. These are small glands near the kidneys, pictured in Figure 39. They are quickly aroused to secretion through stimulation of the sympathetic system, and the effects of the secretion disappear in an hour or less. They are aroused by any emotion, whether great joy or great anger or sorrow, and their secretion has three important effects. (1) It causes the liver to release its stored glycogen or sugar, which provides an easily assimilable food for the muscles and other tissues. (2) It increases the tendency of the blood to coagulate. (3) It produces a constriction of the small blood-vessels. These together prepare the body for vigorous action. The glycogen rapidly restores the fatigued muscle, and the constriction of the vessels increases the blood pressure and thus increases the irrigation of the muscle by the blood. This washes away the fatigue products more rapidly and so diminishes the effects of fatigue. The increased coagulability and the constriction of the blood-vessels diminish bleeding in case wounds result from the fighting which usually follows emotion in animals. One may look upon the entire group of responses as elements in the general preparation of the body to meet the demands of a crisis that produces what we call an emotion.

In addition to the responses controlled by the autonomic system, emotional expression also involves many of the voluntary skeletal muscles. The most important of these socially are the facial expressions. They are used in painting and on the stage, together with gestures, to express the different emotions. Recently many attempts have been made to analyze the elements of the expression by Langfeld, Piderit, Feleky, and others. The results have been only

partly successful, for it is found that observers agree only as to the most general characteristics of the expression. If a group is shown a picture intended to show scorn, for example, guesses as to what emotion is intended will range from anger to exhilaration. Nearly all would agree in general as to whether pleasant or unpleasant emotions were intended, but within a narrower range the percentage of correct answers was reduced to forty per cent in many experiments. All agree with Dunlap that the eyes and upper part of the face in general contribute less to expression than does the mouth and lower portion. This and the general uncertainty of judgment seem to be the only result of the experimentation.

While, then, the bodily accompaniments of emotion are varied and widespread, we are still a long way from being able to assign any specific set of responses to any emotion. Contractions of voluntary muscles under stimulation of the central nervous system, contraction of unstriped muscles excited through the autonomic system, secretion of ductless and ordinary glands, inhibitions of movements and of secretions, together with the changes in respiration, circulation, and general nutrition which depend upon the reactions and secretions, all are evoked by what we call emotion. But we still cannot say that any particular reaction or any Note secretion or group of reactions or secretions is characteristic of what we call a single emotion. The most diverse responses accompany the same emotion, and the same responses accompany what we classify as the most diverse emotions.

The whole problem of emotions has been given a different turn by recent physiological work. The bodily responses in emotion are largely aroused through the autonomic

system. This controls the secretion of the glands, the movements of the alimentary canal, the changes in the blood vessels, etc. Three divisions of the autonomic system are recognized: the cranial which supplies the head and upper portion of the chest and laps over upon the alimentary canal; the sympathetic which supplies the middle portion of the body, and the sacral which supplies the lower, the portions of the alimentary canal, the sex organs, and lower abdomen in general. Cannon and others have suggested that the cranial and sacral divisions are dominant in pleasant emotions, or in situations in which the environment is easy and the body can be built up, while the sympathetic is called into play by seasons of storm and stress. It rules in fear, anger, and hate. It overlaps upon the organs controlled by the other two and dominates them in an emergency. here.

Action of Cranial and Sacral Autonomic System. — The cranial autonomic when active evokes secretion of saliva, movements of peristalsis in stomach and intestine, and the secretion of pancreatic and other digestive fluids. Sight or taste of food stimulates these to action. The sacral causes contractions in the rectum and the bladder and controls the sex activities. The sympathetic system also sends branches to each of these organs and to most others in the body. While the other two divisions may act upon one organ at a time, the sympathetic system sends its impulses to all at once. It has no directive control. On the whole it opposes the effect of the other two. It causes cessation of secretions of the salivary glands, of the digestive fluids and of movements in the alimentary canal, especially of the peristalsis. It dilates the pupil of the eye, whereas the cranial contracts it, it erects the hairs, and contracts the

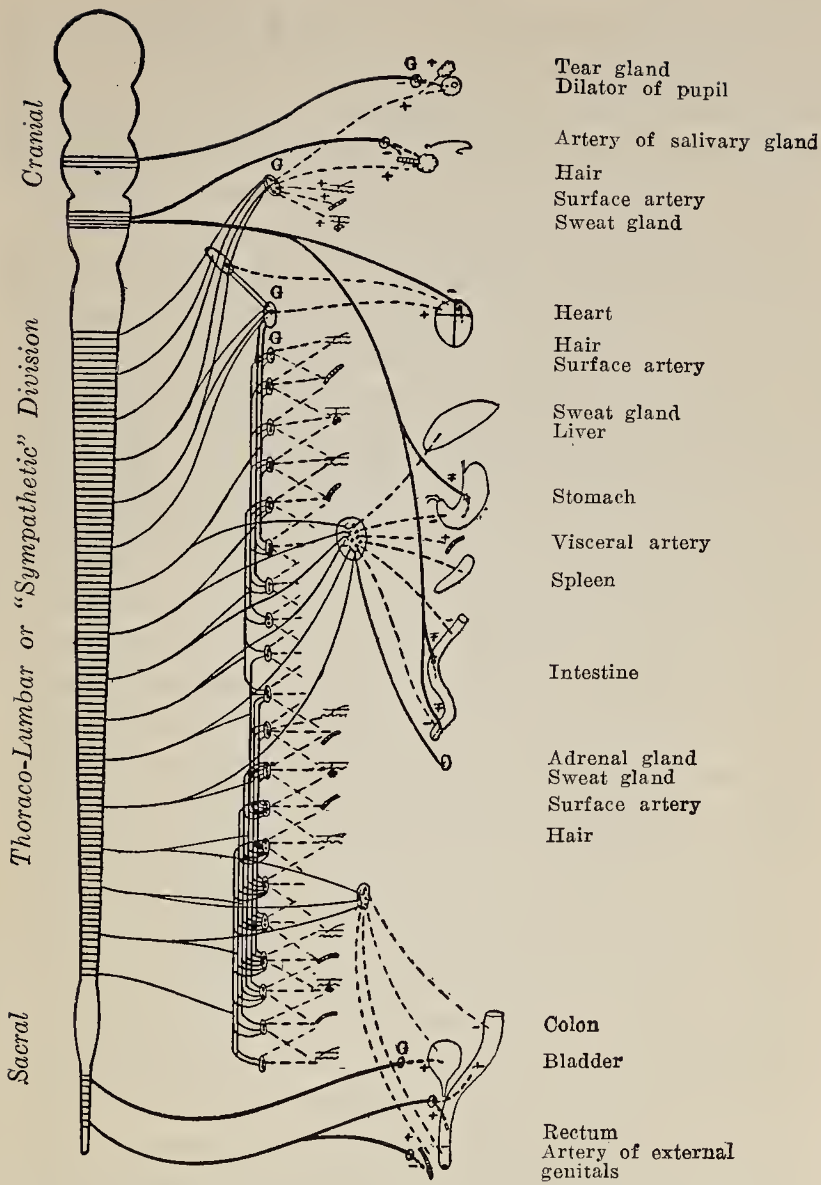

FIG. 40. — The autonomic nervous system. At the right are the names of the organs supplied from each level. At the left are the names of the three great divisions. (From Cannon, *Bodily Changes in Fear, Hunger, Pain, and Rage*, by permission of D. Appleton and Company, publishers.)

This theory makes emotion the subjective accompaniment and the natural outcome of instinct.

small blood vessels all over the body. (If when an animal has been eating and the digestive secretions are active there should come a sudden fright, all these are stopped by the sudden excessive response of the sympathetic system.)

It would be a very simple theory of emotion if one could say that all pleasant emotions were due to the stimulation of the cranial and sacral divisions of the autonomic nervous system, while all the unpleasant emotions, — anger, fear, hate, and their different subforms — could be referred to the sympathetic nervous system. It would make the James theory very definitely applicable. Cannon, however, in harmony with the work of Sherrington, Bechterew, Head, and others, now believes (that one must look to the central nervous system for an explanation of all phases of emotion, rather than being content to find it in the visceral and peripheral changes.) The negative evidence for the view is (1) the belief that the visceral organs are insensitive and even when contractions of different kinds take place, there can be no direct awareness of them. (2) Experimental evidence that animals show emotions in general bodily attitudes and facial expressions when there can be no connection with the viscera. Sherrington cut the cord of a dog so that no sensory stimuli could reach the brain from the abdominal regions and found that the dog would still show by expressive acts both pleasant and unpleasant emotions. (3) Cannon carried the evidence a step farther by removing the sympathetic ganglia from a cat and noting that the cat still showed signs of emotions of anger and fear by bodily posture, although there could be no secretion of adrenalin, no erection of the hair, or change in the blood vessels. (4) Experiments on giving patients large doses of adrenalin indicate that there is no

brain spinal cord.

true emotion, although it may increase the emotion if other occasions tend in the unpleasant direction. When a patient was worried about her children, the worry would increase after the dose. But the drug alone did not give an emotion. The most that a patient would say was that certain of the sensations were similar to those received when undergoing the emotion. (5) Emotions develop before the sympathetic system responds. (6) Many responses are identical in different emotions.

As opposed to the visceral theory, Cannon follows Head and Bechterew in making emotion an accompaniment of the excitation of the thalamus. The evidence for this view is mainly dependent upon a study of cases of injury to the thalamus. When there is a unilateral disturbance of the thalamus, the expression of the emotions may be limited to one side of the face. The injured side will be paralyzed in emotional reactions, although it may be otherwise normal, *i.e.* under voluntary control. That the thalamus serves not merely as a center of emotional expression, but also is an immediate seat of consciousness in emotion, appears from the fact that if the thalamus suffer a ~~lesion~~ injury on one side, pin pricks may produce a very intense unpleasant response on the corresponding side of the body, while they will be relatively slightly felt on the normal side. Pleasant impressions, such as musical tones or hymns, may cause an intense emotional state on the injured side. In fact the pleasurable emotions may become so great, according to Head, that they become unbearable. That these emotions are not due to the backstroke from muscles of the body is shown by the fact that bodily postures and voluntary contractions of muscles are without emotional effect. Cannon thus accepts Head's theory that the thalamus is an immediate seat for

the emotions, that any stimulation of the thalamus produces an emotion, as a conscious state. This emotional state is not dependent directly or indirectly upon the excitation of glands, visceral, or voluntary muscles, but is the accompaniment of the excitation of the thalamus alone.

The Origin of Emotional Expression. — Much interest attaches to the problem of why the movements in emotion take the course they do. The responses are common to all races and to most individuals, in spite of the fact that many seem to have no great utility. Darwin proposed a theory in his *Expression of the Emotions in Animals and Man* that is still as satisfactory as any that we have. He based his explanation upon the assumption that all facial and bodily expressions must be regarded primarily as survivals of once useful movements, whose usefulness has disappeared. In the early stages, crying makes for the preservation of the child, because it attracts attention when it is lost, or when injured or otherwise in need of assistance. The response persists after it has ceased to be valuable. Aside from expressions that have been directly useful at some time in the development of the species, there are transfers of expressions from the original connection to others in which they are useless. Darwin recognized two principles of transfer. First, expressions that have once been really effective acts in a given connection are transferred to other similar emotions. The sneer of a man is the remnant of the unsheathing of the teeth in an animal. The man feels as the dog does in preparing for the attack. He expresses himself in the same way, although it is no longer customary to fight with the teeth. The nod of affirmation is a metaphor that has been transferred from the motion of the head which the child makes in taking food into the mouth; the shake of

the head in negation, a transfer from the child's act in moving the head quickly to avoid taking unwelcome food into the mouth. Darwin's second principle, that opposed emotions are expressed in opposite ways, is of rather less general application. His best instance is the expression of delight or friendliness in the cat. When the cat is angry, it lashes its sides, and crouches for the attack so that it is as inconspicuous as possible. When pleased, the attitude is just the reverse, — the back is arched, the tail is held erect, and everything is as conspicuous as possible. In addition Darwin has a group of expressions left unexplained which he refers to the mere nervous overflow — for instance, the turning gray of the hair from fright (if the fact be accepted), and the standing on end of the hair. Of these principles, the second and third seem less well established. The metaphorical transfer of emotional expression is accepted in some form by practically all and has many applications. The more general principle, that expression is the survival of instinctive responses that were once valuable, is fundamental to all theories. The expressions are slight remnants of movements once important for the survival of the individual in the circumstances which now call out the emotion.

The Classification of Emotions. — The problem of the classification of emotions has occupied philosophers and psychologists since Descartes, and no entirely satisfactory grouping has yet been made. This is partly because there are a number of different principles of division that cut across each other, partly from mere lack of knowledge. If the emotions are the subjective side of instinct and at the same time definite bodily responses, one might base a classification either upon the instincts or upon the bodily reac-

tions. Neither is quite satisfactory, since the bodily responses, so far as known, are frequently much the same for more than one instinct, and the instincts are classified on the basis of the ends they subserve, rather than by the nature of the responses. Three general criteria may be suggested: the quality of the feelings prominent in emotion; whether they refer to the self or another person or thing, and whether the event is past, present, or future. Three definitely distinct emotional expressions are found in love, anger, and fear. One is pleasant, the other two unpleasant; and of the latter fear is passive, anger, active. These fundamental emotions vary in quality as they are aroused by different stimuli or subserve different ends. Thus fear is different from disgust and shame, both in the reference and in the bodily response; jealousy, in the same way, differs from anger; pride and joy, from love. Anger is different from rage, in the intensity of the emotion. Some, as shame and pride, have a subjective reference, while fear and love have an objective. Again we classify in language with reference to the time of the event that arouses the emotion. Thus dread and hope are the future forms of fear and love, respectively; regret and satisfaction, the past forms. Language supplies many minor shadings which are difficult to fit into any logical scheme. Another difficulty in the practical classification of one's own emotions is found in the fact that emotional response to the same situation varies greatly with the intellectual attitude toward it, and this changes often while the situation remains the same. Hope changes to fear and fear to anger in rapid alternation. When one recalls the situation, one is apt to overlook the changes and call the whole response one emotion, — which one depends upon the final outcome.

Emotional Control. — Control of emotion or of emotional expression is largely in terms of the attitude one takes toward the stimulus or sensation. A caress from one person may please or be a matter of indifference, from another may cause anger; what occasions anger in one mood may give pleasure in another mood or attitude. (The attitude is in large measure under one's control) From the nature of the organism and its inheritance, certain objects or stimuli must call out one response, and only one. But aside from these most fundamental instincts, invariably evoked by certain stimuli alone, sensations and stimuli are susceptible of different classifications, and when classified, arouse the emotion that belongs to the class. Whether a remark falls into the group of jests or of insults is often largely a matter of chance, and dependent upon circumstance. The emotions may be controlled only in so far as it is possible to vary the classification of the stimulus. The classification depends very largely upon how one attends.

Does Expression Relieve Emotion? — One frequently hears the statement that free expression relieves or reduces an emotion, while a pent-up anger or grief grows stronger. There is some evidence that a 'good cry' assuages grief. Of interest in this connection is a theory of the Austrian physician Freud that many of the disturbances of mental life come from conflict between instincts that makes one emotional tendency suppress another. A report of Rivers on the nervous disturbance of 'shell-shock' would trace the origin of the disease to a conflict between the natural instinct of fear and the social pressure that prevents a man from showing it. Curious paralyses and disturbances of sensation that excuse a man from subjecting himself to danger, sometimes present themselves in these cases. Eder

quotes the case of an Australian soldier at Gallipoli who was firing through an embrasure when bullets struck several times near his head. He could no longer see with his right eye, although the tissues were perfectly normal. It was interpreted as an instinctive protest against further danger. Whether we accept all of the phases of the Freud theory or not, it seems probable that many of these disturbances can be traced to such conflicts in emotional tendency.

Can Conflict and Repression Be Avoided? — It has been argued from these theories and facts that all conflict in instincts should and possibly could be avoided. We are told that a child should always be permitted to act out his instincts and that he should never be compelled to suppress the emotional expression that corresponds to them. This recommendation is an ideal, but one which can seldom be attained in ordinary practice. Were one to consider the individual alone and then only to insure perfect mental health, the prescription would probably provide a means to that end. (But the fact that individuals live in society, and that the social instincts conflict with the individual makes complete compliance with the rule impossible) Certain emotional conflicts are necessary. There are many cases in which others would suffer did the individual vent his emotions freely and the individual who must live in society would suffer did he form the habit of disregarding others completely. In practice, one learns to compromise emotional conflicts. So much of the rule may be followed as implies not raising unnecessary conflicts for the child or for one's self. The puritan rule that one should practice self-denial for the sake of moral training and against the time when necessity for repression may arise may well be disregarded in favour of avoiding conflict. On the other

hand, often when essential desires and emotions conflict, discipline must be maintained, the social forces must be given a hearing.

Self-Control. — A large part of what is ordinarily called self-control is really control of the emotions. Lack of self-control arises from conflict of emotions, and of the ideals and instincts that cause emotions. Usually either one has disagreeable emotions that are unnecessary or expresses too freely the emotions that one does have. Unnecessary discontent arises from failure to attain to one's ideal standard and this may be due either to having too high ideals, or in not working hard enough to attain them and then wasting effort in regret that might better have been spent on accomplishment. It is necessary, too, to keep in mind human limitations and so not to expect too much of one's self. A cure for any of these evils is not emotional repression, but elimination of the fundamental causes. The cure is to be found either in reducing one's ideals or increasing one's accomplishment by better methods of work. To reduce ideals is difficult, more difficult than one thinks. If it were too successful it would reduce efficiency by diminishing effort. A well-balanced soul may attain the same end by accepting the difficulties and at the same time striving for the end. To regard all effort as part of the day's work, with no stigma attaching to failure and not too much credit coming from success, is the ideal attitude, although, if not in harmony with temperament, it can be attained only as a result of long habit. Even in this prescription there is danger that it may lead to a cynical depreciation of the advantages of success that destroys ideals, or on the other hand that it may merely repress the emotion, either as a pose that will have unpleasant social consequences, or, if

the repression be real, that it may incur the dangers emphasized by Freud.

The other alternative is to permit one's self free expression at all times, to be perfectly ready to face the facts and willing to experience the emotion that logically or instinctively follows from them. Where one is dealing with misfortunes that are real and inescapable as in the death of relatives and friends or the loss of one's health and capacity for work, free expression is the only rule. (Here, too, the emotion may be diminished by occupation of mind and body which will distract from the remembrance.) In certain cases the emotion may be transformed and find a useful outlet in something that symbolizes one's own grief as in charitable work. The usual rule of looking on the bright side has much to recommend it, provided only that it does not lead to falsification of the event and so store up new troubles for the time of realization or lead to suppression and the consequent mental and physical ills. Usually a grief boldly faced yields to the development of new habits that replace the old ones disturbed by the misfortune, and the formation of new ideals and complete readjustment follows. Readjustment must come some time and the sooner the better. (Perfect honesty with one's self as with others is best in this field as in all others.)

Transfers of Emotional Response. — That reactions may be carried over from one situation to others similar to or in some way connected with it is proved by experiment and by observation in normal and abnormal individuals. The conditioned reflex, mentioned in Chapter V, is an instance. Evidence of similar transfers is abundantly supplied from common experience. Much of the pleasure or its opposite obtained from the articles of daily use is derived from their

associations. So marked and so frequent are these transfers in the mentally abnormal that one school of psychiatrists sees in them the prime evidence of mental disease. The disturbances are connected with emotions aroused by memories of early crises, but the memories themselves frequently do not come to full consciousness; they are assigned to objects that have become symbols of the event. Thus in one case reported by Dr. Morton Prince, a woman was profoundly depressed by the sound of church bells and could not account for the effect. Careful examination by special methods disclosed the fact that the sound had been closely related to the death and burial of her mother, which had occurred under peculiarly distressing circumstances. Such instances of transfer of emotion from one object or event to others only indirectly related to them in the life of individuals are suggestive of the possibility of a similar transfer of expressions from one event to others of the same class during the long course of evolution.

Emotions Dependent upon Intellectual Appreciation. — Not all emotions can be explained directly by this theory of instinctive response. Certain emotions, it is true, come without preliminary consciousness, and the response may be contrary to desire or even opposed to all rational expectations. James' fainting at the sight of blood is typical of this class. But we have many emotions which arise only after interpretation, which are influenced by contemplation as much as by the stimulus. Many times one does not become angry until one sees who is playing the trick; one is not afraid until the full list of circumstances is taken into consideration. One sees a snake and at first feels only curiosity. Later when the markings are noted or the rattle on the tail, one begins to grow cold, to shiver, to feel a

sinking in the abdomen, and all of the other symptoms of fear. The reflection upon the stimulus, not the stimulus itself, seems to be the cause of the reaction. This does not mean that the bodily response is not an essential part of the emotion, even that it is not the most important element in colouring the emotion; but it does mean that in addition to the instinctive contractions or as a cause of these contractions, one must consider the wider intellectual setting, if one is to give a full explanation.

The Intellectual Emotions. — Two classes of emotion may be distinguished in which these intellectual factors are important. In one, interpretation consists in referring the stimulus to a known class. When the reference is completed, the instinctive response is immediate. Fear of the snake or anger at the trick is delayed until the reference is made, until the situation is understood, then the instinctive response comes at once. In the second class the situation threatens no immediate danger and promises no immediate benefit, and the response could never have been of survival value in a similar situation in the pre-human stages of evolution. Most of our emotions in peaceful civilized life are evoked by winning or losing prizes of symbolic value only. One is elated over school or social honors, one worries at loss of money or of the social prestige that goes with money, one grows angry at deprecatory remarks about one's self or one's family. No one of these can be explained directly as vestigial instinctive responses once of value in protecting the individual. It is the rule that emotions are now due to success or failure in the attainment of ideals established by social convention. Originally they might have been connected with the attainment of ends of survival value, but in many cases the connection has become very remote.

The organic response in these must be thought of as transferred from a similar situation in which it was fitting. It is the principle of the ' conditioned reflex ' mentioned often in earlier chapters. In our present life situations seem to have been grouped into conventional classes, each class with its appropriate response. Unjust deprivation of anything becomes a cause of anger and the response always comes, it matters not whether the thing of which one is deprived is a dinner or an intangible something regarded as an element in the total reputation. The insinuation that a pet theory is not all that one has thought it may cause as violent a reaction as a physical injury. The transfer of the response from situations where they might be of value to those only remotely similar may be regarded as metaphorical and as expressions of Darwin's first law mentioned above. In discussing emotion, then, we must consider the knowledge and ideals of the individual as well as his instincts. Emotional responses are evoked by a total situation in the light of intellectual appreciation rather than constituting instinctive responses to a single stimulus. With this addition, emotion may be defined as the awareness of the instinctive response. It is the consciousness of the reaction of the individual as a whole to the situation as a whole.

Mood. — Closely related to emotion are mood and temperament. Two uses of the word mood must be distinguished. The first designates an emotion of long duration and of slight intensity. A mood is an affair of hours or days where an emotion lasts but minutes or hours. Moods may arise from physical conditions. Indigestion or other physical ills predispose to unpleasant emotions, good health to pleasant emotions. They may also be induced by pre-

ceding pleasant emotions or even ideas. Start a day with a successful endeavour, and a pleasant mood may follow.

Temperament. — More permanent tendencies to emotional response are called temperaments. The temperament determines for the duration of life the probable reaction of the individual to different environments. A recent study by Kretschmer furnishes a working classification of individuals with reference both to the bodily and mental characteristics. He would divide all men into cyclothymes and schizothymes. The cyclothyme is physically short and broad with a tendency to plumpness. Emotionally he is lively, good natured, sociable, and unrestrained in his expressions. He is objective in his attitude, not too set in his opinions, nor particularly consistent and logical in his actions. He may alternate quickly from gay to sober, but neither is taken too seriously. The schizothyme is taller, with sharp features and spare. He exhibits little emotion. One seldom becomes fully acquainted with his motives. He is distinctively of the 'shut-in' type. He reaches his conclusions logically and sticks to them rigorously. He tends to the ruthless in argument and action. Both types have men of distinction, even genius, but the cyclothyme attains his end more naturally and good naturedly, the schizothyme doggedly, logically. Roosevelt was a typical cyclothyme, Woodrow Wilson, a schizothyme.

These differences can be traced through families for generations. They color the normal life and indicate the type of insanity to which the individual is most liable. In fact, Kretschmer first noticed the distinction from studies of insanity and then transferred the types to the normal individuals. They can also be related to the ductless glands. These are likely to be over-active in the cycloid,

and to be normal or deficient in the schizothyme. Mood and temperament both may be coloured by the thyroid secretion in particular. When the glands are over-active the individual is easily excited, and when deficient, he is dull and apathetic, with reduced emotional responses of all kinds. In discussing temperaments, it should be insisted that there is no sharp line of distinction between groups. The cyclothyme and schizothyme as described mark the extremes, but the great mass lies between, shading gradually over as one or the other tendency dominates. More careful statistical study is necessary before we can be certain of two centers of distribution, corresponding to the types.

EXERCISES

1. Give an instance of an emotion and of a feeling. How are they different?

2. Recall some strong emotion. How did it affect the accuracy of your thinking? The efficiency of your acts?

3. What are the characteristics of the James theory? Can you think of any objections to it?

4. Can you recall any instance of true emotion without bodily reactions?

5. How are the motor responses in anger different from those in fear? In joy from those in hate?

6. Distinguish the physiological effects common to all emotions from others peculiar to certain emotions.

7. Do the bodily expressions precede or follow the emotion as a mental process?

8. State the evidence for adrenalin secretion in anger, in fear. Are they different in degree?

9. Can the emotion or its expression be repressed or modified? Does experience change the original character of the emotion or its expression? How does it resemble instinct in these respects?

10. Why does sorrow over failure to win a social honour have the

same bodily expression as sorrow over losing a bit of food? Why does loss of a sum of money have the same effect?

11. Describe the facial expression in anger, in joy, in sorrow. Does the facial expression contribute anything to the quality of the emotion?

12. What relation exists, according to Kretschmer, between the bodily form and temperament?

13. Pick out among your friends five individuals who are short and stout. Do they fall into the cyclothyme group in temperament? Select five more who are of the athletic or asthenic build. Do they incline to the schizothyme temperament?

14. Is there any relation between the thyroid over- or under-secretion and disposition?

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CHAPTER XIII

ACTION AND DECISION

All that we have discovered concerning thought, perception, and particularly concerning feeling and emotion makes an important contribution towards the understanding of action in its higher forms. We may consider in this chapter the more deliberate and considered types of action as opposed to the simpler forms of response which were discussed in the early chapters. We may take for granted what was learned there. That all action is initiated by stimuli from the world outside or from within the body, that certain tendencies to response are determined by connections present at birth, but that most are developed by practice in the life of the individual. We saw there that learning in an animal was by means of selection from diffuse movements evoked by stimulation, and that the selection was due to the immediate preference of the animal for one rather than another of these movements or of the ends to which they led. All deliberate action involves the use of these established habits and makes use of the fact that the memory of the stimulus has the same effect in arousing a movement as the stimulus itself. We may consider here the methods of modifying movements as seen in deliberate learning or acquiring skill, and especially the ways in which man controls his simple movements in more complicated situations, and especially the factors that determine the selection of one act rather than another.

Learning Entirely New Movements. — Learning by trial and error was seen to be the usual method of learning in animals and children. In the adult, with his thoroughly established system of habits, the same method is operative and may be extended even to learning to make movements that seem to have been lost in the human species. Thus, one cannot ordinarily move the ear muscle, but by trying through actually moving muscles in the neighbourhood, the nerve impulse will in time find its way to that muscle and it will begin to move. It moves slightly and only in a small percentage of trials at first, then with a wider sweep and more frequently, until finally it is completely under control. Of a similar nature are the cases in which surgeons interfere with the normal course of nerves or the normal attachment of tendons and compel the patient to use the nerve or muscle to produce the opposite of its natural movement. If a nerve to the muscles that flex a member has been destroyed, it is possible to divide the nerve that supplies the muscle which extends the member. In time the patient will learn to bend the member although the nerve current that induces the contraction must go over the nerve that originally induced the opposite movement. Similarly, when a muscle that flexes a member has degenerated, the surgeon may connect the tendon of a muscle that previously extended the member to the point of attachment of the incapacitated muscle and in time the patient can bend the member with part of a muscle that previously extended it.

The Overflow of Motor Impulses in Effort. — A large factor in learning of this type is the overflow of nerve impulses from the direct paths to other related ones. It was noticed in connection with voluntary attention that

there was a widespread contraction of muscles whenever attention became difficult. There is a similar strain during the early stage of any learning process. The small boy's hand as he learns to write is tense. This tenseness spreads to a large number of muscles not concerned in the act. He may move tongue and head in rhythm with the hand. All this is due to the spread of the motor nerve currents from the one path to other more or less closely related ones. When one tries to move the ears for the first time, one naturally moves the jaws or the scalp tensely and awkwardly. This brings the overflow movements. When one of these chances to stray into the nerve that leads to the ear muscle, that muscle contracts. Then that particular act can be repeated at each trial. Finally the path to the ear muscle becomes the central one and the other contractions overflow from that. When great skill is acquired, the ear may be moved alone without any overflow. The trial and error in these cases is below the level of consciousness. It consists in chance wanderings of nerve current. The only part that can be noted is the attainment of the end. When the end is attained, thought of the end tends to induce the movement, occasionally at first, and more and more frequently, until each thought of the end is immediately followed by its attainment.

Learning as Transfer. — After a fair number of movements have been learned, the first attempts at a new movement are more nearly successful. If the child has had some experience with a pencil in drawing, the first attempts at writing will not be so awkward as the first attempts at drawing. The movements will all resemble the desired result. At this stage, the known movements most like those to be learned will be used first. Still, the method of

modifying the old to obtain the new follows the same laws as the original learning. One first makes some similar familiar movement, and then tries to vary it until the end is attained, but the modifications are struggled for in the same random way as in the original learning. Many trials and numerous discouraging failures are usually required before the desired modification presents itself. When it comes once, it can be called out a second time only after numerous trials. Each success makes new successes more likely, but perfection in any movement comes slowly. When one begins to learn the golf stroke, one ordinarily has a number of similar movements at command. One has swung an axe, or has cast a fly, or practiced hitting at pebbles with a stick. One calls upon some one of these on the first occasion for hitting the ball. The probability is that the first attempts will be inaccurate; certainly they will be feeble. The process of transforming the familiar habits into adequate new ones is one of constant trial and slow selection of the successful variations. In the more complicated and delicate movements of this sort, one frequently does not know what it is that makes the stroke successful. The conscious antecedents of the successful stroke seem to be very little different from those present in the unsuccessful, but practice brings the successful stroke more frequently. Assuming, then, that an individual has a large number of impulses under control, whether they have been established by earlier practice or are instinctive, we find that new movements are learned by slow and painful modification of these responses.

The Acquisition of Skill. — Closely related in explanation and in practice to the learning process is the acquisition of skill. When one has mastered the separate movements

necessary for the accomplishment of some important end, the process of combining them and controlling them in such a way as to give rapid and accurate accomplishment offers much that is of interest psychologically, and also much of practical importance. Many investigations have been made of the methods of acquiring skill in telegraphy, in typewriting, tossing balls, and in various other games and occupations. The rough results show striking agreement among the different investigators, and for different sorts of learning. Learning has a characteristic course. One may represent it by the curves, showing the rate of learning the telegraphic language in Figure 41. It will be seen that progress is step-wise all through the test. First, there is a rapid increase in skill during the period when the elements are being learned, then there is a period without progress, then another rise, and so on. There are alternations of rapid improvement with levels of practice without improvement. These level parts of the curve have been called the plateaus. It should also be noted that in the first part of the experiment the curve is much steeper than later. One gradually approaches, but never absolutely reaches, the highest performance of which the individual is capable.

The Curve of Learning. — The mechanism of learning and the explanation of the course of learning are also fairly well agreed upon. In the first place, methods by which improvement is made are seldom conscious. One falls into good habits and gives up bad habits with no knowledge of how or why. The man does his best all the time, and at times he improves, at times he continues upon the same level; he himself cannot tell how the improvement was brought about. He does not ordinarily plan out the improvement; he hits upon it by chance. More interest-

ing and consequently more discussed is the explanation of the plateaus in the learning curve and the occasion for rising from one level to another. All seem to agree that, during the period of no improvement, associations are being formed that are to be useful at a later stage of learning. One can advance to a certain stage only on the basis of one definite group of habits. When this stage has been reached, no

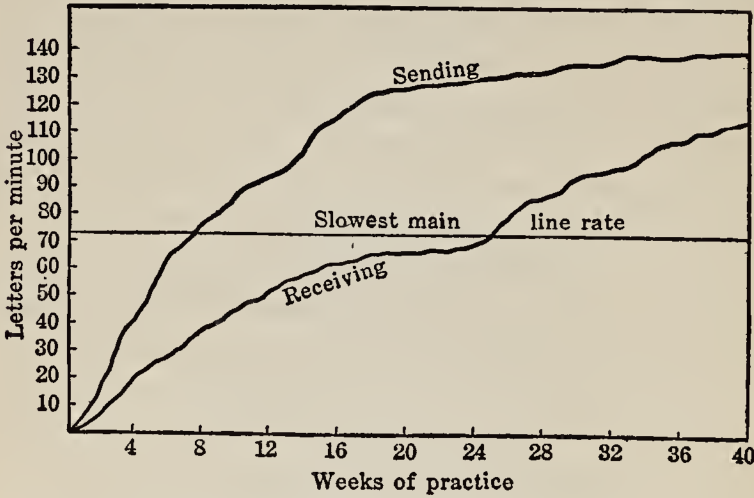

FIG. 41. — Shows the increase in letters per minute that can be sent and received by a beginner, as he acquires skill. (From Rexroad, *General Psychology for College Students*, after Bryan and Harter.)

further advance is possible until new habits have been thoroughly established. During the time one keeps to the plateau the habits are being stamped in. After they have been thoroughly established, it is possible to go on to higher acquirements. Apparently, the learner works just as hard when he makes no progress as when he is advancing. And while the effects of the work do not show in the accomplishments, something is being gained all the time that will tell finally in new progress.

Improvement in Performance Sudden. — Very interesting is the question of what gives the sudden rise in capacity. Sometimes, apparently, it is the result of effort. It is said by Bryan and Harter that a telegraph operator may stay for years at a small office and make no appreciable gain in his sending or receiving rate, but when transferred to a larger office where more demands are made upon him, he will suddenly increase in skill. In this instance, progress is the result of effort, and effort of increased incentive. But effort does not always lead to increased accomplishment. If one strives hard for a new advance before the habits are ripe, the result usually is not advantageous; one is more likely to disturb the ordinary habits and lose efficiency than to gain new skill. Effort is necessary for the rise to a new level of speed, but effort is harmful before the necessary amount of preparation has been made by fixing old habits. The advance may be accompanied by relaxation of effort; the work seems easier when the advance begins. Another element of value is to become clearly aware of the details of the movements that are made and of what parts are essential. It is the rule, in learning new and effective combinations, that they are hit upon blindly, and only later become consciously recognized. With the recognition, one is apparently prepared for a new advance. But the actual improvement that gives the advance is ordinarily some new chance combination that develops unintentionally, and is not appreciated when it comes. In some cases the plateau seems to appear when certain parts of the complex movement are being learned separately, and the sudden rise is apparently due to success in uniting them into a single whole.

Still another factor that is probably as important as the

acquirement of new combinations is the disappearance of bad habits. Failure to advance may be due to the persistence of some unfortunate habit acquired early in the task. In the course of time this bad habit may disappear, and the record will jump up suddenly to a new level. Both the development of a new and advantageous habit or set of habits, and the disappearance of some bad habit that has been retarding advance may be unnoticed. They are not planned in advance of their appearance, and are not recognized when they appear. All that can be said of the method of acquiring skill is that one must continue to work up to his best capacity, and must be constantly on the lookout for any new method that may promise advance; but, in spite of one's best endeavour, there will always be periods of apparently fruitless effort, plateaus of no advance, and the advance to new levels will come unexpectedly and for no assignable reason.

All learning is by the same law of chance trials, and selection of the suitable movement when it is hit upon by chance. The first learning is by the selection of movements connected as overflow discharges with the original instincts. When a fair number of these have been fully established, new movements are acquired by chance variations from those already learned. Finally, when all of the movements involved in a complicated set of activities have been learned and one desires merely to combine them in the best possible way to obtain speed and accuracy, the combinations and connections are again developed by chance. Ordinarily one does not know, either before or after, how the various advances in skill are made. In learning one can only keep trying and be alert for the appearance of the satisfactory movement or combination, when it makes its appearance.

This, with constant striving to obtain some result and to repeat the result when obtained, is all that can be done toward learning. In time it is bound to be successful. It should be added that learning must be spontaneous. Unless the movement is made by the individual, no learning results. Movements forced upon an animal or man by a trainer or by electrical stimulation are learned slowly, if at all. To be learned, movements must be hit upon in the course of intentional effort. There is no short cut to learning.

Motion Study in Industry. — That the worker knows little of the movement that he actually makes is indicated by the fact that careful study of the movements made during a factory operation always shows much lost motion. Many of the economies in modern management are the result of detailed study of the movements made by an operative, and then determining which of these can be eliminated to advantage. The trials are adjusted to attain the end, but the worker knows so little of the movements made in the attainment that he does not appreciate how they may be improved. Careful adjustment of the movements of a bricklayer increased the number of bricks laid from seven hundred per day to three thousand, with little extra exertion. Similar results have been attained in many operations with machines in factory work. When studies of motion pictures show where motion is lost, the worker is shown the most economical movement and is made to learn that movement and eliminate all others. Or the machine and its accessories are changed to make the shorter movement necessary or natural. The worker still learns the elements of the movement by trial and error, but the pattern is set for him by careful study, and he is watched

to see that he struggles until he hits upon the economical pattern.

Control of Movement. — The second question is how movements are controlled when once they have been learned, and why one movement rather than another is made on any occasion. It follows from the law of the connection of motor and sensory nerves that control of movement must always be primarily control of idea or control of sensation. The process of learning is to associate movement with a sensory process; when the connection has been established, the movement results whenever the related idea or sensation dominates consciousness. The immediate antecedent of a movement is ordinarily an idea. In speech, the expression follows upon the thought of the words. In repetition of spoken words, the expression comes when the word to be repeated is heard. Similarly in writing from dictation, as one hears the words the hand traces them upon the paper. The writing may go on fairly accurately when no attention is given to the words. The student in a lecture may take notes without knowing much of what he is writing, while thinking of the next football game, or of other extraneous matter. The connection between the auditory region and the motor region serves to keep the hand writing properly, whether all attention is fixed upon the movement or not. The immediate antecedent of the movement is always some idea, but, in addition, two other groups of sensory processes must coöperate in the control of the movement. These are, in James' terms, the remote sensations, sensations from the eye or ear, and the resident sensations, sensations which 'reside' in the muscles and other parts of the moving member.

Remote Sensations. — As one writes, the pen is guided by the sight of the movements that are made. If the pen

wanders from the line, one sees it and brings it back. With the eyes closed or in the dark, writing is very uncertain. In speech, the ear takes the place of the eye. The voice is modulated by the ear. When a discordant sound is started, it is checked and the vocal mechanism adjusted to give the desired quality. The deaf speak in monotonous, badly modulated tones because they cannot know what sounds they make and so cannot change them. Children born deaf are dumb because they have no incentive to speak and no means of appreciating the sounds they make. They can learn only when they are taught to control the movements of the vocal organs by touch. Education of the deaf in the art of speaking is necessarily a slow process. They must be taught to reproduce the movements of the teacher's mouth and larynx as they feel them with their fingers or see them in the glass. Otherwise learning follows the usual laws. After they have reproduced the movement by chance and know through touch that they have made it, the idea of the word, however it may be presented, will lead to the reinstatement of the movement. Later they substitute the sensations that come from the moving muscles for the tactual sensations. This never becomes as adequate as the control that is exerted by the ear of the normal individual. The deaf child always is deficient in intonation and modulation.

Resident Sensations. — In addition to these impressions from the higher senses, sensations from the moving member serve to control all movement. The best evidence of this statement is the fact that when the kinæsthetic sensations are lacking, control is inadequate. Tabetic patients, whose Columns of Goll and Burdach in the spinal cord have been destroyed by disease and who in consequence have no sensa-

tions from the muscles, may tend to make a movement and have the appropriate idea, but the movement will not follow, or will be weak, or entirely misdirected. A child whose sensory nerves in the organs of speech have not developed will not learn to talk unless special methods are devised, and then will learn slowly and imperfectly. The sensations from the muscles and the moving parts are constantly coming in to exert an influence upon the amount and character of the motor discharge. They adjust the movement to the position of the member at the moment, and exert a general guidance upon the movement.

The Incentive to Action Takes Many Forms. — Each of these directing and controlling factors may be explicit, or each may be implicit; each may be conscious or unconscious, or vaguely conscious. It has been asserted at different times that the initiating idea must be a kinæsthetic memory of the act, that it must be a picture of the member in a certain position, and that it may be any one of several definite ideas or images. The more the antecedents of action are observed, however, the more evident it becomes that the directing idea may be any sort of image whatever. In many cases, the imagery is very indefinite, seems to be very largely lacking. It may be a mere thought that it is desirable to do a certain thing; it may be any part of the act to be performed. In other cases, one may make up one's mind to do a certain thing at a certain time, and when the time comes, one does it with no appreciable idea whatever. The expected sensation starts the movement decided upon without any idea or intention intervening. Thus, at the moment you read these lines, we may imagine that you decide to underline them. You may think of the position your hand should take to bring the pencil to the

proper point on the page, and you may think of this position in kinæsthetic imagery or in visual imagery; or, you may think merely in words, 'I'll underline that,' and draw the line with no further imagery whatever. Again, you may have decided at the beginning of the reading that you will underline the important passages, and now think nothing more than, 'this is important,' and the movement starts at once. The general rule is that there is more imagery the first time a movement is made, and that the imagery decreases in amount the more frequently the movement is repeated. In general, too, each part of the movement is at first preceded by a separate idea, while, after several repetitions, all that is necessary is to think of some part of the movement or of something that makes the movement desirable, and it is executed without further outlining of the details. Such a general thought as, 'that is important,' is the usual cue for the more familiar movements.

Controls Often Automatic. — The controlling sensations, resident and remote, act even less consciously. As one underlines, one is aware through the eyes of the course of the movement; one sees the lines grow, but does not realize that these visual impressions play any important part in the control. The control is not conscious and deliberate. One does not first appreciate the visual sensations, and then decide in terms of them how the pencil must move to make the line straight. One occasionally notices that the line is getting crooked and consciously corrects it; but, if all goes well, the only way of being sure that sight is guiding the movement is to find that one cannot draw the line in the right place with the eyes closed. The influence of sight is effective, not only in determining the direction and character of the movement, but also in determining its force or

intensity. One of the most striking instances of this is the illusion of the pound of lead and the pound of feathers. A pound of feathers seems very much lighter than a pound of lead, because the large bulk calls out a strong motor discharge for the feathers, and the small bulk of the lead a slight motor discharge. In consequence, the feathers are lifted very rapidly, the lead very slowly. The weight that rises more rapidly than was expected seems light, the weight that rises more slowly than was expected seems heavy. For our present purpose, the important phase of the experiment is to show that the motor impulse is controlled in amount by remote sensations. Sensation may overcome knowledge. If one is told in advance that one object is light, the other heavy, the illusion persists on lifting. Even when told that each weighs exactly a pound, the large mass still calls out the larger impulse, and is raised the more rapidly. Given only the intention of raising the weight, the motor impulse is determined primarily by the visual appearance of the object to be lifted; other sources of knowledge will be disregarded.

The same sort of control by vision may be seen in many other movements. In speaking, one unconsciously adjusts the loudness of the tone to the distance of the listener, the size of the room, etc. In making a golf stroke, the force of the blow is guided by the sight of the green, together with the unexpressed estimate of the distance. In each of these instances, the strength of the movement is closely adapted to the visual impressions, and the only requirement for the adaptation is that the weight to be lifted or the object to be hit be definitely looked at, or have been observed just before the movement. The control by the kinæsthetic sensations, the resident sensations, is similarly unconscious. One

never thinks of them unless attention is especially directed toward them, and even then one is more likely to be conscious of the visual interpretation, to think of the motion of the member in remembered visual images, than in terms of the kinæsthetic sensations themselves. One misses them when they are destroyed by disease, but does not appreciate them when present. Three elements, then, combine in the initiation and guidance of a movement. (1) The general idea or intention to move. This is found in the thought of the movement or of the end to be attained. (2) The remote sensations from eye or ear. (3) The resident sensations from the moving member itself. These resident and remote sensations control the direction and force of the movements.

Not All Ideas Produce Movements. — If, as has been said, the immediate antecedent of a movement is an idea, the question naturally arises why all ideas do not lead to movement or, more particularly, how it is possible that one may think of a movement without making it. One may think of saying something and not say it, one frequently thinks intently of an act without performing it. This problem has been much discussed but has received no very definite answer. The probability is that there is no particular process that comes invariably to set off the movement after it has been decided upon, but any one of a number of different circumstances may serve as the final determinant of the movement. Of these, the most important is the wider setting in which the idea presents itself. If everything else in the situation favours the movement, it will be made; if the idea of the moment is altogether out of harmony with the act, it will not be put into execution. Thus, if one has been waiting for the summons to dine, one goes

immediately to the table when it comes; if the summons comes in the midst of writing a sentence, the movement will at first be thought of vaguely, but nothing will happen. Sometimes a contending image or idea may interfere with full attention to the movement itself, or other considerations may make the act undesirable at the moment. When these disappear, the act results. It is probable, when everything seems ready for the movement but it is not made, that the explanation is to be found in some inhibiting process, some vaguely conscious consideration that blocks the path.

The Release of the Movement. — One of the best chances to study the play of these forces and considerations is in getting up in the morning, which is made much of by Professor James, and which, for its difficulty, seems to have universal appeal. When the alarm goes off, one intends to get up, one even thinks of the movements that are to be made in their order, but nothing happens. Sometimes one suddenly recalls the task that must be finished early in the morning. That gives the required impetus, and the various habitual movements are begun. Often, however, one thinks of nothing new; there seems no particular incentive to the movements just before they begin; one finds one's self dressing and that is all that there is to the whole matter. In such cases it is probable that the act begins when some inhibiting or blocking idea disappears or is forgotten, that the movement is due to the removal of a check rather than to the appearance of a new force. In brief, the movement is induced, not merely by the idea regarded as the motive, but by the entire mental context at the moment, that is by a large number of elements that constitute the situation and the attitude toward the situation. In any case the

release of the movement does not follow upon any definitely assignable mental content, but is the outcome of a whole mass of considerations that combine to make the act desirable.

Reaction Times. — A method much used to analyze the action processes is to measure the time required for the execution of different kinds of acts. The subject is asked to touch a telegraph key as soon as he hears a sound or sees a word, or is touched. An electric circuit is started through a clock as soon as the stimulus is given. The circuit starts a clock, which registers thousandths of a second, and the clock runs until the movement breaks the circuit. The time required for this simplest movement varies greatly with the sense from which the stimulus comes and with the degree of complexity of the response required, as well as with the individual used. Reactions to auditory and cutaneous stimuli vary from 0.120 to 0.170 seconds, while the reaction to a visual stimulus requires from 0.150 to 0.200. The difference is largely due to the slower response in the eye itself. It is also found that the response is much quicker, in many cases one-tenth of a second quicker, if attention is fixed upon the moving member, than when it is upon the stimulus. In the latter case the motor adjustments must be made in greater degree after the stimulus is received. When the subject is attentive to the member, it is kept in a condition of strain, ready to move when the stimulus comes. In all cases the subject is prepared in advance for action. He is given a signal two seconds before the stimulus to be ready. This enables him to have complete attention and an adequate bodily adjustment. Were this not given, the times would be longer and very irregular.

Compound Reactions. — When more complicated acts must be performed, the times are longer. Thus, when one must discriminate between two letters before one moves, the time is increased by from 0.05 to 0.15 second. The greater the number of letters to be discriminated, the longer the time required. The discrimination may be made either by asking the subject to wait until he is sure which of two or more letters is shown before he reacts. Or he may have his discrimination controlled by being requested to respond with one finger when one letter or color is given and with another when a second color is seen. This is sometimes called choice time. It is interesting to note in this connection that the more the choice is restricted, the quicker is the reaction. Were one left free to make any movement whatever, more time is taken than when one is told to make one of two movements.

Association Times. — The time required for associations has also been measured. A word is shown and the subject told to speak the first word that comes to mind. The time varies here very widely, from half a second to two or three in extreme cases. Again the wider the range which is permitted for the association, the longer is the time required. If a man is told to give the class in which an object belongs he will respond in one-half second or less, while nearly a second may be taken to name a member of a class, and to name the first word that comes to mind may require three-quarters of a second or more. In all of these reaction processes it is seen that the movement is started by a stimulus, but the preparation for the movement is made in advance. The preparation is similar to that in attention. There is a general preparation for one class of responses rather than another in all cases, and there may be a definite prep-

aration of one single group of muscles. This is the case for the simple reaction. The more definite the preparation, the quicker the movement.

Will and Choice. — The rudiments of action are, then, comparatively simple. One acquires the possibility of moving by random movements that give a certain result, and the connection between the idea of the movement and the movement itself is established by frequent repetition. At all later times, the movement may be made whenever the idea comes to consciousness. The more complex problems of action are really problems in the control of ideas. What one ordinarily calls will is exerted primarily in the control of the course of thought, and action follows when the proper thought presents itself. The most striking instance of voluntary control is the decision between alternative courses of action. Frequently two courses present themselves which seem equally attractive or impelling. Decision in these cases is made by selecting one of the two possible ideas. You choose the result of one course of action or of the other. This may lead in turn to the thought of the movement necessary to realize that end. Always what is chosen is not the movement as such, but an idea; either the thought of the result, or the thought of the movement dominates consciousness at the moment of choice. When either completely fills consciousness, the action results. Control of action offers nothing that has not been discussed earlier in connection with the control of ideas, or with attention, — the selection of sensations. The importance of action, however, makes it desirable to study the old laws in the new application.

The Mechanism of Choice. — When making a choice between two courses of action, one thinks of the probable

results of each and chooses the one which offers the greater probability of a desirable outcome. If after class it is a question between going home or to a shop, you do not think of the movement as such, but you decide that it is necessary to finish the task at home at once, while your purchases may wait until later in the day. When this decision has been made, the necessary movements are begun at once. The same holds of the more complex life problems. Choice of a profession, where there is opportunity for choice in the matter at all, is a choice of ends. The advantages and disadvantages of each profession are weighed and compared with the difficulties that must be overcome in obtaining a preparation for each. When a balance has been struck, it finds expression in some phrase, such as, 'this will be my lifework'; from that time the first step toward the entrance upon the profession is kept in mind, ready to be translated into action when occasion arises. The idea, and the idea alone, is chosen at the moment; translation into action may be delayed for years.

The Conditions of Choice. — If we turn back to ask what it is that makes one line of action attractive and the other repulsive, we can do no more than enumerate different elements in heredity, education, or present mood. In action as in attention, two classes are to be distinguished, — one due to interest, the other to social pressure. The one is said to be in accordance with desire, the other to arise from duty. Desires grow out of hereditary tendencies and experience, and change with the mood and attitude. Duties, on the other hand, come mostly from social influences, from ideals, and are relatively permanent. The actions from desire promise immediate satisfaction; actions from duty are attractive from their more remote results.

The outcome of the line of action decided upon always seems at the moment of choice to promise the greatest amount of good, immediate or remote. The only difference is that the preliminaries are in the one case irksome or even disagreeable, while in the other they are pleasant, even though the final outcome be not so pleasant. The conditions of non-voluntary attention are also the conditions of desire; the conditions of voluntary attention are the conditions of duty.

Choice Determined by Wide Ranges of Experience. — Concretely, if one ask why last night one continued at a game instead of turning to work at the accustomed hour, the answer would be found in the instinctive pleasure in the game, or in the pleasure of the society, or in the excuse derived from experience that the fatigued condition would make study at that time prejudicial to good work on the morrow. The first two occasions for the decision lead back to heredity, to instinct, while the latter is an expression of experience. Suppose that the game had been given up and one had turned to work, the explanation would be found in social pressure, in the dominance of ideal or remote pleasures over the instinctive and experiential. One would have considered the unpleasantness of confessing ignorance before fellow-students, or one would have had in mind the desire to stand well at the end of the college course, or would have considered the importance of that lesson for success in the chosen profession, or, still more remotely, one may have developed an ideal of doing well everything that is required. Even this last ideal probably has a social origin, although, after social approval has rewarded action in harmony with that ideal or punished departures from the ideal sufficiently often, action in accordance with it becomes

a habit, and there is ordinarily no thought at the moment of the decision, either of the ideal or the consequences of the action. One turns to work because one feels that one must, because one feels uncomfortable if the game is not given up. To perform the accepted and acknowledged duty is essential to immediate comfort. The factors, then, that determine choice are, on the one hand, the instincts of the individual, corrected by his experience, immediate and remote; and, on the other, ideals derived from society. Ultimately the social factors go back to experience, so that one may assert that choice is the outcome of instinct and experience. Conflict of desires is merely conflict between motives developed through experience or inherited, each of which tends to make a corresponding course of action desirable.

High and Low Motives. — The conflicts most important and most emphasized are those between instincts and instinctively pleasant habits on the one hand, and ideals on the other. On the whole, it seems at first that the acts favoured by instinct are low and unworthy, while the acts imposed by society and ideals are high and moral. The opposition is only apparent. Some of the acts in themselves noblest, such as certain forms of self-sacrifice, are instinctive, while society has endeavoured at times to enforce altogether unworthy ideals. The apparent conflict arises because society emphasizes acts in themselves unpleasant which need all of the social enforcement possible, while the instincts, good and bad alike, are strong enough to take care of themselves. Society imposes rules where instincts are insufficient, or have in practice proved undesirable, or less desirable than a method of conduct that has grown up through trial and error and been transmitted from generation to generation by tradition and social institutions.

Where instinct and tradition and social institutions come into conflict, all the strength of public sentiment is needed to enforce traditional and conventional acts against instinct. In consequence, a premium is put upon them by calling them high and noble, while the instincts are either considered unworthy or are taken for granted.

Selection Is between Instinctively Pleasant Acts. — As a matter of fact, instincts mark out only the rough outlines of conduct. The limits to instinct, or the demarcation of one necessary instinct from another, is not given in the instinct, but must be learned by the individual or society. We have egoistic and altruistic instincts, but there is nothing in instinct to show how far one should be selfish, and how far sympathetic on particular occasions. These checks and balances must arise through social intercourse. When they have developed, they are just as important for the survival of the social group as are the instincts themselves. These acts enforced by social pressure are said to constitute duties, as opposed to desires which are largely instinctive. Choice, then, is always choice of a result. Often one finds that choice is the outcome of a conflict of desires with duties, of instincts against ideals. At other times, choice is nothing more than a weighing of the alternative methods of attaining an end that is approved both by desire and duty. Decision is in terms of past experience. The end that has proved most successful in the past or that promises best in the light of the knowledge of the agent will be chosen and will result in action.

Will Identical with Conditions of Choice. — So far we have not made use of the word 'will,' although, in popular and much scientific discussion, will is the word used most frequently to explain action. Will, as Angell says, is merely

a word to designate the whole mind, or better the whole man, active. Will may be defined as the sum of the conditions of choice. It is the term used to designate the entire original disposition of the individual, together with its modification by experience, when applied to action. It is no new force or thing; it is the application to the control of action of all the influences that control attention, perception, and the course of ideas. Even here, these forces control attention and ideas first, and control action only as they control attention and thought; but since action is practically the most important or at least the most striking psychological phenomenon, the term 'will' is usually reserved for action. Ordinarily will is not applied to all of these forces, but is reserved for the ideals that enforce social traditions and laws. When one acts under the control of an ideal or for the accomplishment of a remote end, one is ordinarily said to have performed a voluntary act; when one gives way to a desire of an instinctive nature, one is said to have acted on impulse. On the other hand, one is said to have acted voluntarily, if the act that corresponds to the ideal has been deliberately weighed against the desire, and the ideal has won. In general, voluntary acts are those which grow out of a conflict between instincts and ideals, in which ideals prevail.

Will as Controlled by Ideals. — Again, one may see in the application of the terms strong and weak will the tendency to identify will with control by ideals. A strong-willed individual is one who works tenaciously for a remote good, while the weak-willed individual is one who is constantly turned aside by some momentary desire. Tenacity in holding to a purpose is probably inherited; the character of the purpose is the outcome of training. The strong-willed

individual may be good or bad, but he always has an ideal or set of ideals, and bends all of his acts to their attainment; while the weak-willed individual is controlled, not by his ideals, but by instincts and impulses excited by the changing factors in the environment. The ideals that control in the strong-willed man are developed by living in society; they are very largely the ideals of the particular community or family in which the individual has grown up, modified and enlarged by the wider knowledge of the individual obtained in any way whatever. You can see in the talk of the young boy the ideals of his parents. Later these ideals are modified by the school influences; still later by his reading; and then by the chosen profession. Now and again, as the result of thinking, an individual decides that the ideals of the community are wrong, and sets up for himself some modification of them; but important variations of this sort are relatively rare, and, before they become of value, must be tested and accepted by the wider social group. In general, the ideals of the individual are the ideals of his community.

Controlling the Action of Others. — Much of modern business consists in controlling or attempting to control the acts of others. The salesman must keep the desirable side of the merchandise constantly before the purchaser and not let him become distracted by something else. He must commit him as soon as possible to the purchase and give him no opportunity to withdraw. The suggestions should be made without giving occasion to think that they are being forced. Inducing morale in a business is a similar process. Here more must depend upon the competitive element and in giving incentives that will work continuously and spontaneously upon the employees. Rewards

may be offered for the best work either by special recognition or by extra pay. In any business all must feel that they are working together for a common end, that the success of the business is the success of the separate employees as well. The man who can induce this attitude in a group becomes the successful executive.

In certain diseases we have a condition in which all will seems to be lacking, a symptom known as aboulia. The patient seems not to be able to bring himself to any act, however simple. Fear of any activity seems almost to paralyze action. Whenever an act is contemplated, some difficulty is thought of that makes it seem impossible. For its cure it is necessary to require simple acts at first under the influence of strong incentives. After the habit of action in these simpler ways is established, the habits may be extended until the patient resumes his normal trade or profession. A large factor is restoring confidence for action by showing that simpler tasks can be performed. When confidence is established again, more difficult things may be accomplished. The retraining begins by proving that simple acts can be performed, to give confidence. On this confidence more complicated activities may be built. Then the original habits may be reëstablished. Similar methods must be used with children at times, and may even be used with one's self when one has fallen into bad habits of work or of not working to the full.

Training of Will. — Training will is, in the last analysis, training the man. Any sort of learning will have its influence upon action. The more one knows, the better one can act, and training for action cannot be separated from training of any other kind. Three topics may be discussed in this connection as having particular bearing upon the

problem. First, we may say that choice is very frequently a matter of habit. If one of two alternative lines of conduct has been chosen once, that decision, if the outcome be satisfactory, will make the same choice probable under the same circumstances in the future. In the adult most choices are of this habitual kind. One no longer hesitates between work and exercise. During the period habitually devoted to work, one ordinarily declines invitations to a game; when invited to walk at the hour for exercise one accepts just as immediately. One declines to consider investments suggested by the canvasser at the door, or coming from certain firms which have been sending questionable circulars. In short, most of the decisions of to-day were settled by decisions of the same kind made years ago. One moral decision strengthens a man to resist similar temptations in the future, and a large number of decisions of the sort makes it practically impossible for him to decide in the wrong way. On the other hand, when a man relaxes his standards in one act, he makes future right conduct in that respect more difficult, and each immoral act makes the reformation more unlikely.

A second important phase of training will is in developing a system of ideals. This can be done only indirectly. Ideals come unconsciously from the society in which the child is brought up. If the boy finds that his father and older brothers constantly disapprove of certain acts and approve of others, he takes their approval for law; their ideals become his ideals. The effective moral ideals come from the approval of groups and classes. As may be seen in any community, right and wrong are made by public sentiment, not by law. A law is respected only so far as it is backed by public sentiment. This holds for moral laws

as well as for statutory enactments. Development of ideals is largely through social approval and disapproval of the acts and expressions of the child. Proper ideals can be developed by placing the child in the proper social atmosphere, and in no other way. This atmosphere is most effective when it comes from actual contact with people. Books and reading and direct exhortation may gradually have an effect; but unless you can make the child feel that the class to whom the ideals belong is actually his class, reading and precept are of little value.

A third difficulty is to make the individual act up to the knowledge and ideals that he possesses. Every once in a while one observes an individual who knows the right and approves, but does wrong. The only cure for this condition is to develop a habit of action. This can be done most certainly by making the child appreciate the advantages of action and the disadvantages of inaction. An individual left to take the natural consequences of his acts will soon develop a habit of doing the thing that he sees should be done, at the time that it should be done. It is only the individuals who are protected from the consequences of inaction and indecision who continue inactive in the face of acknowledged duties. If a habit becomes established, there is no longer question whether a thing shall be done or not; the situation at once evokes a decision, and the decision evokes the act. Training will consists in establishing habits and in developing ideals. All training, of whatever sort, is bound to develop both habits and ideals; training of will cannot be distinguished from training the man as a whole.

This discussion of action adds but one essential fact to the list developed in the earlier chapters. This is that a

movement is associated with some sensory process and is made whenever that process dominates consciousness. The movement either is associated with the idea or sensation at birth as in instinct, or becomes associated with it through the process of chance trial. The control of action is primarily control of ideas or of sensations. Except in this fact, that movement follows upon idea, the laws of action are the laws of attention, of perception, and of reasoning.

QUESTIONS

1. Describe the characteristics common to all actions. What are the forms of action? What serves to distinguish them?

2. Enumerate the antecedents of a voluntary act. Which can be regarded as the real cause of the act? Is it a cause or an accompaniment of the cause?

3. Do you ever think of a movement without making it? What prevents the act?

4. Can you control a reflex act? How?

5. How do you choose? What do you choose? What makes you desire to do what you choose to do?

6. What is 'will'?

7. Trace out the instinctive, experiential, and ideal elements in some real decision you have made during the day.

EXERCISES

1. Try to develop some movement that is latent. Try, for example, to wink your right eye without closing the left. Keep a record of the number of trials, and watch the spread of the contraction from a neighbouring muscle. First try keeping attention fixed upon the eye to be kept open, then upon the eye to be closed while the other is neglected. Which is the more effective? If the movements of the eyelids have already been dissociated, try patting your chest with one hand while you rub the top of the head with the other. Keep the same records.

2. Trace the process of acquiring skill with the cup and ball. Keep a record of the proportion of successes over a period of several days. Trace plateaus and the occasions for the sudden rises. If more convenient, any other simple game of skill may be substituted for the cup and ball.

3. Procure two objects of the same weight but of unequal size, and try to train yourself to lift them at the same rate. Can you avoid the illusion of weight or rid yourself of it by practice?

4. Try writing, while with hand hidden from direct observation you watch the writing in the mirror. What is the effect? Which of the three controls mentioned in the text is disturbed in the experiment? Can you overcome the difficulty with practice?

5. Study yourself while making a high dive. If several attempts are necessary before you start, try to trace the immediate antecedent of the action. If diving be impracticable, observe getting up on a cold morning, or getting into a cold bath.

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CHAPTER XIV

WORK, FATIGUE, AND SLEEP

One of the most frequently mentioned phenomena in connection with work, either mental or physical, is the tendency for it to become distasteful if continued and the belief that the amount of work that can be done decreases in amount and in quality if it is long continued. If you study hard continuously for four hours, you begin to feel that you have done enough. This is partly because you have unpleasant sensations in various parts of the body, partly that you become bored, and partly, possibly, that attention tends more and more to wander off to something else. We ordinarily assume that this dislike of work comes because continuous activity impairs in some way the physical mechanism so that the capacity for work is diminished. Not all authors accept this explanation, however. Thorndike among others insists that there is no real impairment of the organism by continuous work but that the individual becomes bored. The work loses its power to satisfy. More effort is required to hold attention to the work, but, if one succeeds in attending, just as much will be accomplished and without permanent injury.

Fatigue versus Ennui. — Thorndike bases his statement in large part upon the work of Arai, who added for twelve hours without rest and did about half as much during the last hour as in the first. She found it more difficult to hold herself to the task, hence the decrease. It induced a dis-

taste for continuous adding that has prevented her from ever attempting to confirm the result by repeating the experiment. Two possibilities are open. One is that there is an actual decrease in capacity that is compensated for by effort; the other is that there is no decrease in real capacity, but some unwillingness to work one's best after a period that has been conventionally accepted as long enough. There is also the possibility that one can keep going for a long period and then have a sudden cessation of work in spite of the greatest efforts. Painter found that after a hard day's work he could add at fair speed from 11 P.M. to 3 A.M. and then suddenly could do no more. Even if he tried easy combinations, he could obtain no results. In the most extreme fatigue, simple mental and physical processes can be carried on for a time at about the normal rate, then there is a sudden incapacity. In some experiments on the effects of loss of sleep over from forty to one hundred twenty hours, the subjects carried on the tests as well or almost as well as in a rested condition, although incidental acts showed marked incapacity, — for example, drifting into a dreamlike state and talking nonsense, when asked questions. All this makes it seem that doing work, even at a constant rate, would not necessarily show that there was no reduction of capacity.

Indirect Evidence That Fatigue Is Real. — In industry a number of measures more or less direct indicate that there is a real reduction of capacity as a result of work. It is not necessary to raise the question whether mental and physical fatigue are different. Most industrial operations require processes that we ordinarily call mental, like strict attention and memory. Most of the mental tests, so-called, also require records that are made by bodily move-

ments. In industry, there is a fairly constant rise in output during each work period which may be regarded as the effects of practice and settling in. Nevertheless the number of accidents per hour rises regularly during each work

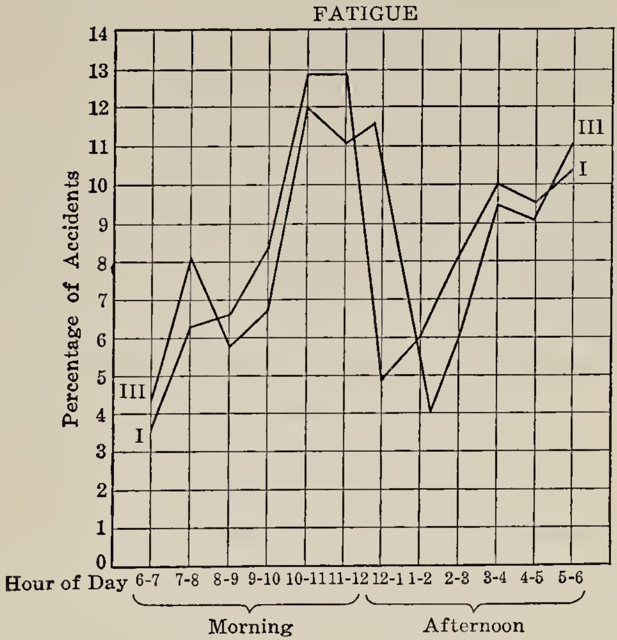

FIG. 42.—Shows the time of occurrence of industrial accidents, (I) in Germany in 1887, (III) in Lancashire, England. It will be noted that the periods of increased output are periods of small number of accidents and *vice versa*, by comparison with Fig. 44. (From Muscio.)

period as can be seen in the curves from Muscio, Figure 42. These may be regarded as due to fatigue. Muscio's analysis indicated that ninety per cent might well be due to fatigue while ten per cent would be definitely assignable to other causes. Inability to avoid accidents progresses regularly during the morning and afternoon periods, while the output

rises just as continuously. Obviously ability to do work depends in part upon other factors than ability to avoid accidents. This would mean that the fact that more or less automatized movements and mental operations are less interfered with by continuous work than ability to hold attention or to be interested in the work. The physiological changes that may be induced and which ultimately reduce or destroy the capacity to do work seem to reveal themselves in a loss of interest and ability to hold attention continuously before they reduce the amount of routine work that can be done. For practical purposes we need not distinguish between boredom induced by monotonous work and fatigue.

Local Fatigue and General Fatigue. — All discussions of fatigue should distinguish between local fatigue and general fatigue. No one questions the fatigue of the muscle or sense-organ actually involved in work. A muscle, excised from a frog and stimulated regularly once a second, soon responds less and will cease to contract after a large number of contractions. Fatigue of the retina shows itself in a blunting of susceptibility, and similar destruction or lessening of capacity shows itself in each of the sense-organs. Each stimulation of a nerve is followed by a refractory period during which stimulation has no effect. In the nerve the recovery from the immediate stimulus is very quick. What we call mental fatigue would correspond to an impairment of the capacity for work in the nervous system as a whole, as a result of doing work. We must seek for direct evidence of the physiological basis of this in various experiments.

Physiological Changes in Fatigue. — The question naturally arises what changes take place in the organism that

reduce the capacity for work or the ability to hold attention and be interested. These changes have been demonstrated for work that is largely physical, but we must assume that they are probably, in many cases, involved in so-called mental work as well. As has been said, mental work is never without physical, even muscular, accompaniments. Physiologically it has been demonstrated that fatigue is

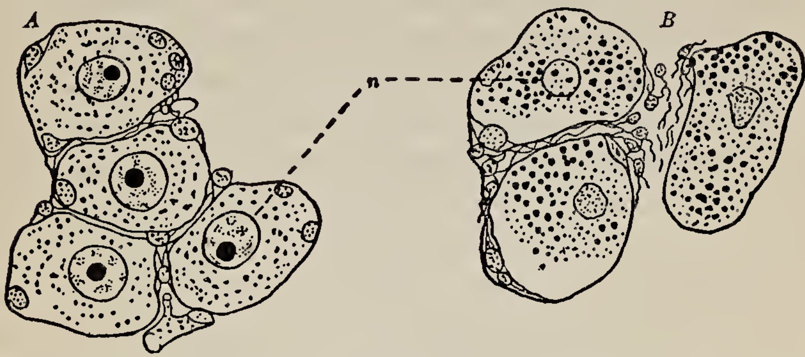

Fig. 43. — Shows the decrease in the nucleus of a neurone after fatigue. (*A*) and (*B*) are nerve cells from the spinal ganglion of a cat. (*A*) shows the resting condition, (*B*) after electrical stimulation of its nerve for five hours. The nuclei in (*B*) are much smaller and are more irregular in outline. (From *American Textbook of Physiology*, after Hodge.)

accompanied by three sorts of changes. First, poisons accumulate in the blood and affect the action of the nervous system, as may be shown by direct chemical analysis. Mosso obtained striking results by an indirect method that is not altogether free from criticism. He selected two dogs as nearly alike as possible. One he kept tied all day, the other he exercised until by night it was thoroughly tired. Then he transfused the blood of the tired animal into the veins of the rested one and produced in him all the signs of fatigue that were shown by the other. There can be no

doubt that the waste products of the body accumulate in the blood and interfere with the action of the nerve-cells and the muscles. It is probable that these accumulations impair the efficiency of the tissues.

Nerve-Cell Deterioration in Fatigue. — A second change in fatigue has been found in the cell body of the neurone. Hodge showed that the size of the nucleus of the cell in the spinal cord of a bee diminished nearly seventy-five per cent as a result of the day's activity, and that the nucleus became much less solid. Crile demonstrated that prolonged loss of sleep induced even more marked changes. Sections made from the central nervous system of animals that had been kept awake continuously for seventy-two hours, showed the walls of the nuclei and even some of the outer walls of the cells broken through. In addition the chromophilic substance is reduced in quantity and much scattered.

Fatigue Products in Muscles. — A third change that results from muscular work is the accumulation of waste products in the muscle tissue. Fatigued muscles contain considerable percentages of these products. That they are important factors is shown by the fact that, if they are washed out of the fatigued muscle, it regains its capacity to contract. The experiments are performed on the muscles of a frog that have been cut from the body and fatigued by electrical stimulation. When they will no longer respond, their sensitivity may be renewed by washing them in a weak salt solution to dissolve the products of fatigue. It is probable that these products stimulate the sense-organs in the muscles and thus give some of the sensations of fatigue. Of these physical effects of fatigue, the accumulation of the waste products in the blood and the effects upon the nerve-cells are probably common both to mental and physical

fatigue. The effect upon the muscles influences mental fatigue only so far as all mental work involves some muscular activity.

The Analysis of Mental Fatigue. — More practical are the results of the experiments accumulating in recent years upon the actual course of work. The change in capacity in the course of work has been shown to be dependent upon a number of factors that may be isolated. First we have fatigue, the decreased capacity for work, which may be assumed to increase regularly with the amount of work accomplished. But this decrease in capacity is partly obscured by another effect of work just as well established, the resulting practice. Every bit of work not only diminishes capacity but also gives increased efficiency for the same sort of work, the effect of practice. These two factors, practice and fatigue, may be regarded as always present and always opposed. The result is that each obscures the other. When work first starts, practice increases more rapidly than fatigue and in consequence one can do more after working for a little time than was possible at first. The course of recovery from the two effects is very different. Recovery from fatigue is rapid. It is ordinarily entirely complete after a night's rest and begins to be appreciable as soon as a task is finished. On the other hand the effects of practice persist over long periods of time. Days and years after, some of its influence may be noticed.

Inertia, Incentive, and the End Spurt. — Two opposed factors are important in determining the course of the practice curve, — one may be called mental inertia, the other the incentive. When one first starts a task, work is difficult and slow; as time goes on, work gradually increases in

amount and accuracy. When once started, work proceeds at the regular rate and stopping may be difficult; or more truly, it is easier to continue work than it is to stop and begin again. Then one may distinguish the initial and final incentive. One works very much harder when first begin-

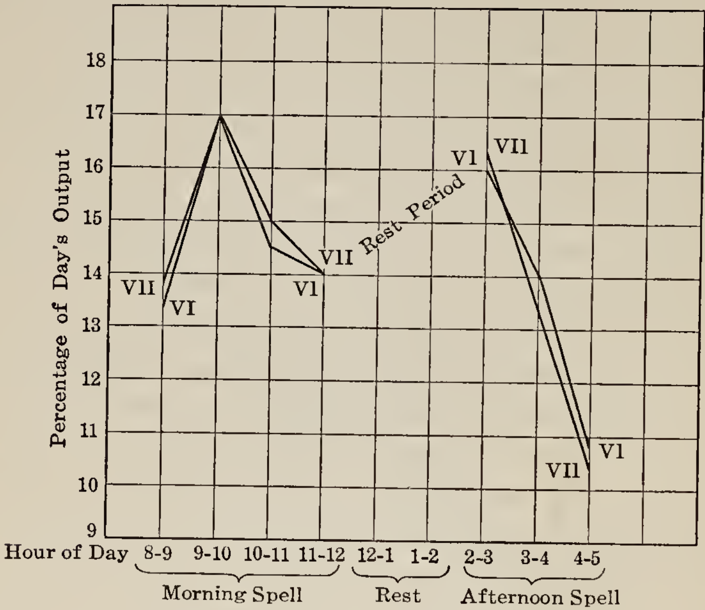

FIG. 44.— Shows typical distribution of output over the working day. Work of Italian typesetters. (From Muscio.)

ning a task than later. Toward the end there is nearly always a final spurt that again increases considerably the rate of work and the amount accomplished. Finally, as one becomes accustomed to the conditions, one works to better advantage than when first beginning.

The Work Curve in Industry. — Careful observations of workers in various industries, many of them made by the British government during the last war, indicate much the same course of work for the working periods of each day

and for the week as a whole. Each morning there is a low output at first, which increases gradually throughout, save for a slight diminution during the last hour. This means that practice increases more rapidly than fatigue. In the afternoon, output is lower again for the first hour, and rises in the same way, except that the final hour shows a more marked decline. In heavier work, such as charging blast furnaces, the decline in the afternoon begins after the second hour and progresses steadily. The noon break causes a loss in the practice effects that for the first hour more than overcomes the recovery from fatigue. The end spurt appears in many industries where wages or patriotism offered a marked incentive. In other cases the distraction of thinking of what is to be done after work and actual preparations for leaving obscure the effect.

The Course of Output for the Week. — The different days of the week show a similar increase. It is lowest on Monday and increases to Thursday, then holds approximately steady for Friday and declines markedly on Saturday. In several cases this was assumed to be due to the fact that it was the custom to pay the workers on Friday night and the resulting misuse of the Friday evening. One might argue from the fact that the product was less on the hours and days immediately following an intermission, that shorter intermissions or even much lengthened hours for the day and an increased number of days in the week would give a greater output per hour. Careful study of the effects of increasing the hours under the necessities of war conditions showed that Sunday work did not pay in any but the lightest operations and for the stronger workers. Vernon reports that women turning fuse bodies actually produced more in a 55-hour week than in a 60-hour week, and more

in a 60-hour week than in a 66.7-hour week. For men at the lighter forms of work and those in which the speed is closely dependent upon the speed of the machinery, there is usually an increase in the rate per hour with decrease in the number of hours, but not sufficient to compensate for the smaller number of hours worked. Regarded solely from the standpoint of maximum output, the optimum number of hours per day will vary with the type of work. That the fatigue in industry is partly what we ordinarily call mental is probable from the fact that telephone operators, whose work is in very slight degree physical, follow much the same curve as factory workers. We need not distinguish carefully between the physical and mental factors.

The Economical Periods of Work. — The most economical period of work is that which gives all the advantages of continued work without going on to the point of fatigue. It is of course impossible to give any general rules that will apply to all kinds of work and to all people. How much work may be done depends upon the nature of the work and upon the strength of the individual. The fact that one does more after working for a little time than when one first begins holds universally. How long one should continue after the effects of fatigue are greater than the benefits of practice depends upon the kind of work and the practical necessities for its completion. Fatigue itself is not to be avoided, for the lesser degrees wear off in a short time and are entirely overcome by a night's sleep. The poor work that results when fatigue is too great makes effort unprofitable, and the after effects, in the form of overwork, may have such serious results as to put a premium upon avoiding them at all reasonable cost.

The Evidence of Fatigue. — It is not at all easy to know

when one is in danger of permanent injury from work. Fatigue shows itself by sensations of different sorts, some from tired muscles, some of a more indefinite character from the inner organs. These sensations, however, are not always associated with fatigue itself. Often one feels tired when actual trial shows no marked incapacity for work. Rather it is usual for the best work to be done when the sensations indicate a state of bodily inefficiency before work is begun. Even the capacity for doing work is not an invariable sign, because it is not unusual to be able to do good work when the organism is fatigued to the point where continued work will do injury of a permanent character. One must be guided by taking into consideration three factors, — the sensations of fatigue, the quality of the work, and what previous experience has shown to be the probable after effects. It is usually inadvisable to persist to the point where a night's rest will not remove fatigue and restore the original capacity. Certainly long-continued work beyond this stage is bound to have serious consequences.

The Best Period for Rest. — To know how long to rest between periods of work is as important as to know when to stop. Results of experiments indicate that the length of the rest that should be introduced between the periods of work depends upon the length of the previous work and upon the character of the work. The rest should be long enough to permit recovery from fatigue but not to lose the mental momentum. After long periods of work, two hours or more, the most advantageous intermission is approximately fifteen minutes; for relatively short periods five minutes has proved itself most satisfactory. Longer periods waste too much time and cause a loss of inertia and

of practice that is not compensated for by recovery from fatigue. Shorter rests merely cause loss of inertia without any compensating rest. Industrial experiments show some quite remarkable results from introducing well-chosen rest periods in mechanical work. A manager who compelled his men to rest two minutes after driving each ten rivets, increased the accomplishment from 600 per day to 1600 per day. Similar effects have been obtained from suitable rest periods.

Change of Mental Work No Rest. — Several facts that have been suggested by experiments are contrary to the common assumptions of many people. For example, it is generally believed that one may rest through change of work, — that if one has been tired by mental work of one sort it is not necessary to rest altogether, but by changing to something else one may become rested through the change. The one important investigation on this point indicates that the everyday assumption is not in harmony with the facts. An hour's work learning nonsense syllables followed by a half-hour's practice on mental arithmetic, with a return to the nonsense syllables, rests one no more than a continued period of nonsense syllables. This is on the assumption that learning nonsense syllables is no more difficult than mental arithmetic. If one turns from a more difficult to an easier task, one will of course not be so tired as if one had continued with the more difficult. So far as these results can be accepted, it seems that all sorts of mental fatigue are of the same kind, and that it is not possible to rest one function while exercising another. There is so much in common between the different mental operations that all become tired together. It is possible that the commonly accepted opinion to the contrary is due to the

greater interest one may have in a new task. One ordinarily turns from a task only when obstacles have presented themselves or when for some reason the work has become uninteresting. It is possible that the greater interest in the new work and consequent greater effectiveness are mistaken for recovery from fatigue.

Mental and Physical Fatigue One. — Very similar is the attitude toward the problem of the relation between mental and physical fatigue. It is generally believed that one may rest from mental work by bodily exercise, but experiments indicate that capacity for mental work is decreased by physical work if it is too difficult. If one takes a vigorous run or other severe exercise between two periods of the same sort of work, as in the experiments mentioned above, the capacity for mental work is diminished rather than increased. Here as before the effect will depend upon the severity of the task. If the exercise be mild, one will rest relatively just as one does during less difficult mental work. In fact, the whole question of work and fatigue is relative, as one never rests absolutely except during sleep, and even then there is merely gain of repair over waste, not absolute quiescence of all functions. The identity of mental and physical fatigue has been demonstrated many times, both that mental work induces physical fatigue and that physical work induces mental fatigue. One cannot do severe mental work effectively after a hard day of physical labour, and experiments show that one is less capable of physical after hard mental work. This general identity of mental and physical work and fatigue is being recognized by the physician. A patient suffering from overwork as a result of too much study or worry, is no longer advised to take much exercise, but is put to bed or given very little easy exercise.

Of course this does not imply that exercise is not beneficial in health. Exercise is essential to the development and health of the body, and needs no justification. One should not expect to be able to work immediately after exercise, but in the long run its effects are beneficial.

Morning and Evening Workers. — Another interesting result of recent investigations is that there are daily rhythms of capacity for work, — that every one has a certain part of the day during which he has greater capacity. According to one authority, men divide naturally into morning and evening workers. The one group is at its best early in the morning; the other group does not reach its full capacity until toward evening, — the amount and accuracy of the work increases steadily through the day. It has not been determined whether the difference is innate or the result of habit, but in an adult accustomed to mental work one habit or the other is usually readily demonstrated, even if the individual himself is unaware of it. Evidently one should take advantage of the daily rhythm by devoting the best part of the day to the more difficult tasks.

Interest Reduces Fatigue. — It should be added that the measurements of fatigue upon which these statements rest are derived from ordinary routine work under no particular incentive other than to do one's best. It is certain that a sufficiently strong desire would at any stage have brought the rate of work back to the maximum, at least for a little time. Even in muscular work fatigue comes more slowly if the worker has an incentive and the work is interesting. Phenomena of this kind have led Thorndike and others to argue that fatigue is an illusion. That what is called fatigue is really *ennui* or boredom. This conclusion overlooks the very evident after effects of severe pro-

longed work in decreased efficiency over considerable periods and even in diseased nervous conditions. While the amount of work that will be accomplished depends very largely upon the incentive, it does not follow that fatigue is not real and a factor to be considered in the arrangement of the day's routine. The statements made hold for the course of ordinary work where the incentive is constant and not particularly strong. If the incentive is increased, the absolute values given are all changed, but the relative values remain approximately the same. There still comes a time when the amount and accuracy of the work is reduced to a point where work does not pay. In some degree, too, the after effects of the work increase with the amount of work, although probably not in the exact ratio of accomplishment. Work done willingly and cheerfully under suitable incentives is apparently less fatiguing in the long run than a smaller amount accomplished under unfavourable conditions. One may even agree with James that in moments of exaltation one may perform at a rate far above the ordinary level without permanent injury, and at the same time accept the results of experiments under ordinary conditions as a guide for daily life.

Fatigue Inevitable and in Moderation Desirable. — The discussion of fatigue and the methods of obviating it is likely to leave the impression that fatigue is something to be avoided at all hazard. This is far from being the case. Fatigue is unavoidable if one works, and work is essential to all development. As was said in the beginning, work has two effects, fatigue and practice. Practice remains and furnishes the endowment of the individual for all later work; fatigue disappears after a night. The ordinary net effect of work the day after is an increase in capacity. The

general effects of work are altogether desirable. Fatigue is not something to be avoided. The most that is desirable is to consider the laws of fatigue and learn to work to the best advantage. The aim of life is not to avoid fatigue but to accomplish as much as possible with the minimum of fatigue. Fatigue is undesirable only when it threatens permanent injury, rather than when it temporarily reduces capacity.

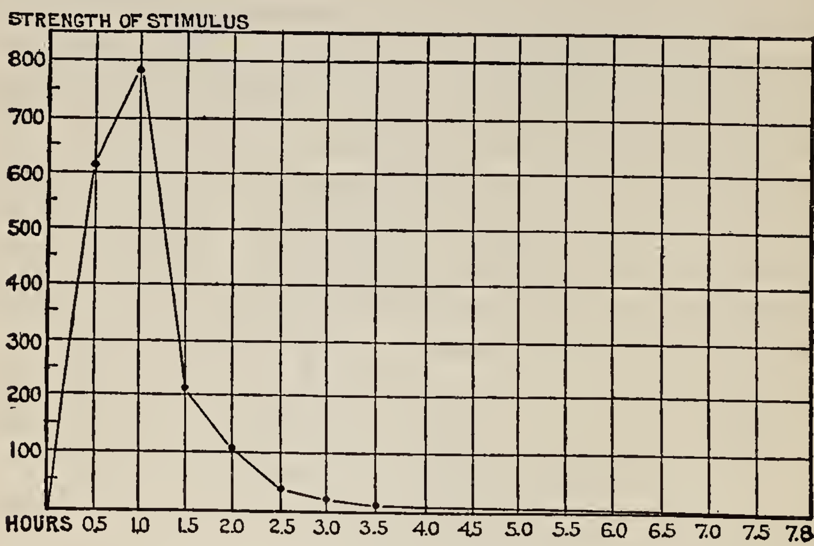

FIG. 45. — Curve showing the depth of sleep at different periods after going to sleep. The figures on the horizontal line show the time since going to sleep; those on the vertical line the relative heights balls must be dropped to waken the sleeper. (From Howell, *Physiology*, after Kohlschütter.)

Sleep. — Very closely connected with fatigue in practice and theory is sleep. While sleep is one of the most common phenomena of life, it is also one of the least understood. What sleep is or why it comes on is as yet not a matter of agreement. Something more is known of the course of sleep and we may begin our discussion with that. Several

experimenters have measured the depth of sleep at different times during its course by determining the intensity of stimulus required to waken an individual. They all agree that sleep increases in depth rapidly during the first three-quarters of an hour and then decreases gradually during the remainder of the night. It has been suggested that the recuperative processes predominate in the latter part of the period, when sleep has passed its climax. Why one goes to sleep is not so easily answered. Obviously sleep has some relation to fatigue, but over-fatigue is inimical to sleep. One ordinarily goes to sleep most readily under monotonous stimulation; but a persistent idea, if more exciting, makes sleep impossible, when all else is favourable. Opinion at present inclines to the view that sleep is an instinct, a form of reaction of the nervous system induced by certain definite stimuli, and that it tends also to recur somewhat rhythmically. This response is favoured by withdrawal of external stimuli, by quiet and darkness, by a moderate degree of fatigue, by relaxed or dispersed attention, and ordinarily through habit is more easily induced at a particular hour. No one of these conditions alone will induce the condition or response, but all together usually suffice. Like many another reaction it is favoured by suggestion or expectation. If one fears one is to have a bad night, sleep is usually slow in coming; while if one expects restful sleep, it comes promptly.

The Physiology of Sleep. — What the reaction is that causes sleep is also much in dispute. Changes have been demonstrated in the circulation. Blood pressure is low in sleep and varies inversely with the depth of sleep, — is lowest when the depth of sleep is greatest. The blood-vessels in the brain are relaxed, although filled with blood,

and constrict when sleep is disturbed or during dreams. Respiration is changed in characteristic ways, and all of the vital processes have their activity reduced. Some change certainly occurs in the nervous system, also, but what its exact character is, has not been decided. Evidence is tending toward the assumption that there is some loosening of the connections between the different elements, such as increased resistance at the synapses to the passage of excitations, but how it is brought about is still entirely conjectural. Certain it is that the nervous system is less easily aroused during sleep and that the course of action is less controlled. Nervous action is not abolished, however, as is proved by the presence of reflexes and by dreams. Whether this reduced activity is due to the changes in circulation, or the changes in circulation are due to the reduced nervous activity, or each is a result of some common cause, cannot be decided from the facts at hand. Whatever sleep may be, it is obvious that it is a state which conduces to the restoration of the tissues that have been subjected to the wear and tear of the day. The effects of fatigue are nullified; the cell bodies are restored to their normal condition; the waste products are eliminated from muscle and blood. On the whole, sleep seems to be an instinctive or habitual response that comes at a more or less regular time, that is favoured by a mild fatigue, and by the absence of external disturbance. During the period of sleep the vital processes are reduced, the higher nerve-centers are only slightly active, and the processes of repair exceed those of wear.

Dreams. — Dreams were among the first phenomena to direct attention to the mental life and have always been an object of interest to the popular mind. For psychology

they emphasize the erratic course of mental states when little controlled. Fundamentally they are an expression of the same laws as the processes of waking life. At times, they are initiated by external stimulation; at other times one can trace the influence of striking events of the preceding day. Thus, cold feet may induce a dream of walking barefoot through snow; a dog shaking the bed may start a dream of a storm at sea. (The images which persist from the preceding day are said by Freud to be the point of origin for all dreams.) Both sensory stimuli and these persisting impressions are ordinarily much transformed. 'A woman who has been carving a duck at dinner dreams of cutting off a duck's leg, but seems to realize that it is her husband's head she is hacking at.' These transformations are usually brought about by associations, sometimes verbal, more frequently through events that have been connected in time or place. Thus a lady who had admired a baby and bought a big fish for dinner dreams at night of finding a fully developed baby sewed up in a large codfish.[1] More frequently the elements added by association are derived from earlier years, sometimes they can be traced to definite early experiences.

Freud's famous theory would make all dreams the expressions of suppressed wishes. According to his theory the unconscious takes advantage of the upper consciousness when it is off its guard in sleep and revels in the wishes which it is not permitted to bring to the notice of the individual in the waking life. In the dream mentioned from Havelock Ellis, the dreamer would be said to have desired a child and the dream gave the fulfillment. Freud supplements his theory with an elaborate symbolism. The ideas of

[1] Havelock Ellis: *The World of Dreams*, p. 37.

the dreams are not what they seem but need to be translated by means of a symbolic code, developed to conform to Freud's peculiar psychological constructions.

The constructions are usually bizarre, since the associations follow lines of least resistance, with little of the restraint from context and wider experiences so prominent in the waking life. The recognition and belief processes are also impaired and one recognizes objects entirely unfamiliar and accepts as true statements and constructions manifestly absurd when tested by the usual standards. This lack of control and uncritical attitude may both be explained from the fact that large portions of the cortex are asleep and the small remainder must both control and censor the mental constructions. One's emotions and moral standards too are often completely transformed, probably also an expression of the reduction in the number of experiences that pass upon the processes. The peculiarities of dreams may be in part due to the great condensation frequently present. The events are merely referred to, and then when the dream is recalled, the references are expanded. It is this that makes possible dreaming of a number of occurrences in a very short interval. We must content ourselves with the statement that they are expressions of the ordinary laws of mental processes, often much exaggerated owing to the weakening of the directing agencies.

QUESTIONS

1. Define fatigue.
2. How can you tell when you are tired mentally?
3. Describe the ordinary course of work. How would rate and accuracy vary if you worked hard for a two-hour period?
4. Can you rest by changing work?

5. Is physical exercise rest for the mental worker? Is it desirable?

6. Is it desirable to interrupt work to rest? Under what circumstances? How long should the rest be?

7. Formulate for yourself a program of work for a typical day based on the statements of the chapter.

8. What is sleep? Is going to sleep a passive or active process?

9. What physiological changes occur in sleep?

10. Recall a recent vivid dream. Trace the different incidents of the dream to physical stimuli and to memories, if you can.

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CHAPTER XV

THE TYPES OF MIND

In practical life we are constantly making rough classifications of men. One hears frequently that A is a man of genius, B has good reasoning ability but little memory, C has exceptional intelligence but lacks push, etc. Obviously, if these types exist, psychology should be in a position to determine their presence scientifically, to measure the differences between individuals in these various respects, and to group them more or less accurately. The practical advantages of knowing the capacities of individuals would be enormous. Could we tell in advance of trial that a man were to fail in one employment, we might spare his employer the expense of training him and the man himself the pains of failure and the waste of time involved in preparation. Could a state know definitely or even within wide limits the capacities of its citizens, it might make sure that each entered the profession or occupation for which he was best adapted and avoid educating men for fields in which they could not succeed.

Conceivably men might be different in degree of ability, in kind of ability, and in the different amounts in which the different kinds of ability were present in each. There might be individuals who were stupid in every respect, others who were geniuses, and others of moderate ability. On the other hand one might have men who could reason without remembering much, others of constructive ability,

but with little knowledge, etc. Were either of these latter groupings of abilities common, it might well be that one could discover fixed types or combinations of abilities and that it would be possible, first to determine the number of types and then to discover some means of recognizing to which type any individual belonged, without trying him in all of the different respects. It has been suggested by psychologists that one may distinguish a slow type with ability to concentrate closely as opposed to a quick, easily distracted type, — that one would acquire slowly, forget slowly, and reason well, while the other would learn quickly, forget quickly, and reach conclusions by intuition. Other types have been assumed, all in advance of test or on inadequate test.

The Meaning of Intelligence. — These questions can be answered only by actual measurements. Measurements of individual differences have been made for the most part in connection with intelligence. Intelligence can be defined only in terms of accomplishment. Men who succeed in the functions that we call mental are intelligent. This success is to be looked upon as due to standing high in a number of different capacities rather than as any special power or function. This should be emphasized strongly, for the great use that has been made of the term lately has led many to think of intelligence as an independent capacity. Nothing of the sort is intended by the present writer nor by most psychologists. In practice it is found that individuals who make a high score in one test also are likely to make a good score in all others. It probably involves all of the different phases of man that have been discussed in our different chapters. The use of the term is justified further by the fact that individuals who do well in these

laboratory tests, also on the average do well in school, and succeed in after life. Intelligence is a convenient term to designate this battery of capacities.

The Measurement of Intelligence. — Attempts have been made to determine intelligence in two ways, each of which has certain advantages and certain disadvantages. The first, most frequently used, is by comparing the individual to be measured with others in a group. If one may assign a man to a certain position in a class of one hundred, there is approximate certainty that he will have about the same position with reference to all individuals selected in the same general way. This is the basis of relative markings in school and college classes. If you grade a man as belonging in the upper tenth in a class of one hundred, you may feel assured that he will have a place in the upper tenth of the community as a whole. Since relative ranking among individuals known well is fairly accurate, estimates of this kind based on daily accomplishment and examination are a reliable index of the intelligence. The exception comes only when the group in which the ranking is made is not representative, which happens when some force other than chance has been operative in selecting it. Thus a man marked average in a college class would very probably still stand among the best tenth of the general population, because the men who go to college have been selected by success in the schools, have on the whole more successful fathers and probably more intelligent parents than the average. The chances are large that a man who stands in the upper tenth in a class of one hundred in one university will also stand among the upper tenth in another university. Relative grades are on the whole absolute grades as well. While this assumption works as a means of determining the ability

of any individual, it assumes rather than proves that ability is distributed in accordance with the curve of probability.

Mental Tests. — The second method consists in putting the individual through some set of tasks, that will be sufficiently different in character to involve different capacities. The first generally used system of testing intelligence was developed by Binet and Simon. The essentials of the method consist in comparing the accomplishments of the individuals in several tests with those of children of different ages. They selected a series of very simple tests and determined by trial upon a large number of children what the average child of a given age could do. The same tests are given to the individual to be tested and his results checked against those of a child of a given age. On this basis it is possible to assert of any individual that he has an intelligence equal to that of the average child of ten or of eight or of five. Terman revised the tests and adapted them to more general uses. He also suggested that one might apply an index that would indicate how children of any age stand with reference to the average intelligence of children irrespective of age. This is the ratio between the actual or chronological age of the child and his mental age. He calls this the 'intelligence quotient' (I.Q.). If a child is ten and passes the ten-year test his intelligence quotient is 1.0. If he can pass only the seven-year test, his I.Q. will be 0.70. If he passes the thirteen-year test, his I.Q. will be 1.30. Adults are all assumed to be sixteen years old for the calculation of the I.Q. The results indicate that the I.Q. holds approximately constant during the growth of the child. This means that the mental age increases in approximately the same ratio as the chronological age, a fact which makes the quotient a convenient measure for growing

children. It is not so satisfactory for the more intelligent adults, as the age tests lose their meaning beyond sixteen and even the arbitrary tests are given only to twenty years.

The Army Tests. — A second form of tests that may be given to a large group was developed during the war. It consisted of a large number of questions that could be answered by any one who had completed the lower grades in school and had had the ordinary experience in American life. It included also tests for quickness and control of associations, tests of ability to follow directions, and for ingenuity in verbal and manual processes. The series of tests was given to a million and three-quarters men among the recruits, and proved very effective in determining the tasks to which they could be assigned. It also gave results that agreed well with the other means of measuring ability, such as salary earned, the character of the calling or profession in civilian life, and the grade reached in school. Since the war, these tests and various modifications of them have been given to students and others and found to offer a good indication of ability to do work in universities and schools in general and also to indicate whether an individual will be successful in different kinds of employment.

The Curve of Distribution. — As a preliminary to any statement about the results of these measurements, it is necessary to consider two general statistical principles. The first is that in any chance collection of individuals of reasonable size there will be represented the entire range of qualities for all of the species. If we select by chance a hundred or a thousand individuals, measurements made upon them will hold approximately of the entire population. The larger the number included in the sample, the more accurately will the selection approximate the result that

would be obtained from measuring all. The second general assumption is that in any large group all characters, including mental capacity, are distributed as are errors in making measurements or as shots at a target. We may emphasize two important characteristics of such a grouping. One is that there are just as many above as below the average, that the distribution is symmetrical; the other that the

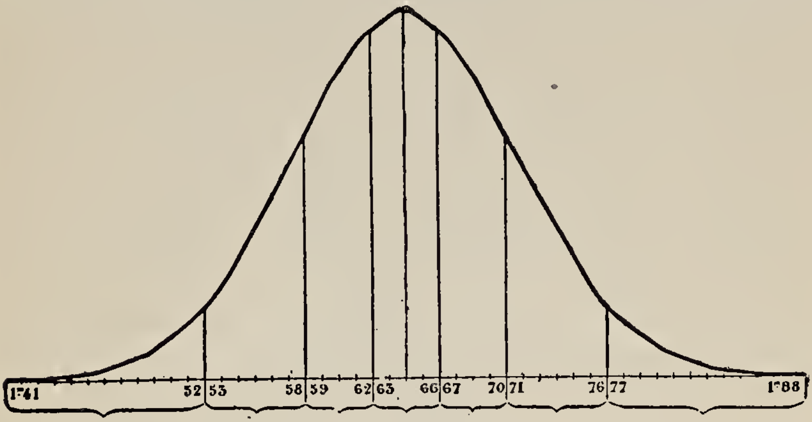

FIG. 46. — The distribution of stature among French soldiers. The distances on the horizontal axis indicate the height in centimetres, on the vertical axis, the number of men of heights between the figures printed below the line. (From Bertillon, *Instructions signaletiques.*)

greater the degree of divergence from the average, the fewer individuals there will be who show this deviation. Thus according to Bertillon, the stature of a thousand Frenchmen would be distributed about 164½ cm., with 236 between 163 and 166, 198 each between 159 and 162 cm. and between 167 and 170, 148 between 153 and 158 and 171 and 176, and only 36 at each extreme between 141 and 152 and between 177 and 188. There would be 10 each below 141 and above 188. The curve which would show the distribution of any physical measurement would have approximately the same form. It is shown in Figure 46. It will be noticed

from the numbers given that there are about eighty who are within a centimeter of each other in height within the three central centimeters and an average of three who are within a centimeter of the same height at either extreme of ten centimeters.

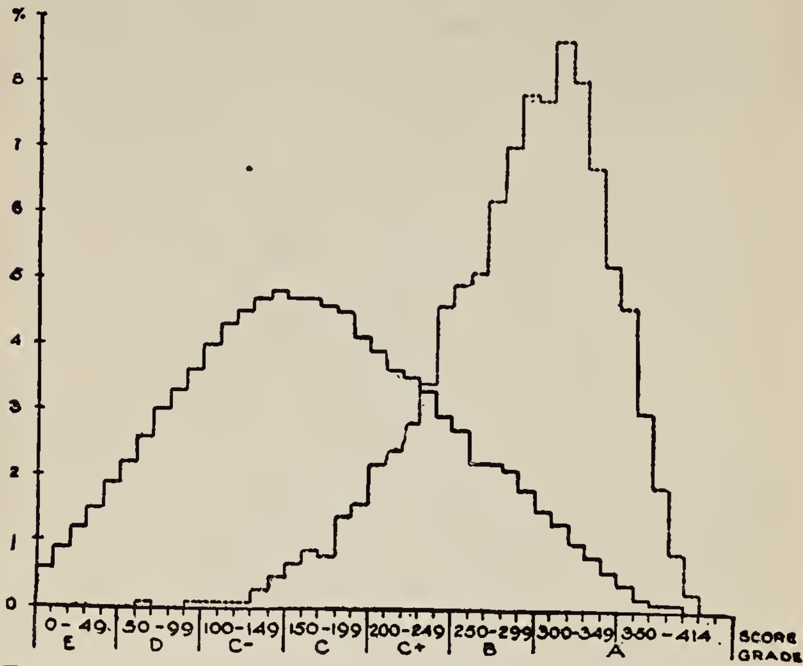

FIG. 47. — Shows the relative success of officers and privates in the Army Test. The steep curve to the right shows the distribution of 5563 officers. The lower curve to the left shows the distribution on a different scale of 63,647 enlisted men. The higher standing of the officers stands out clearly.

Distribution of Intelligence. — Intelligence is distributed in accordance with the same law. Grading any class by a numerical standard shows that there are about as many who make more than ninety per cent as those who fall below a minimum requirement, thirty for example. In any class but the lowest certain of the worst have always

been eliminated, so that the curve of school grades based on a numerical marking is never quite symmetrical. The Army tests showed roughly the same law. The curve that represents the number of men who made each score closely approximates the curve of errors or the curve of distribution of height in the French army (Fig. 46). Making use of the assumption that intelligence follows the normal curve of distribution and comparing the grades made in the test with standing reached in school and success in civilian life, we find that among the men drafted four or five per cent belong in an A group, men who can do superior work in a university and make higher officers if they possess leadership and initiative. Eight or ten per cent can be assigned to a ' B ' grade, men who are capable of doing average work in college and of making successful officers; about sixty per cent to a ' C ' grade composed of men of average intelligence. This grade is divided again into ' C + ' of eighteen per cent who are good high school men, but men who would not do well in college, a ' C ' grade of twenty-five per cent, and a ' C — ' grade of twenty per cent. Measured in school accomplishment, the ' C ' would not do well in high school work, the ' C — ' is of grade school intelligence. A ' D ' grade of fifteen per cent is of normal men of sufficient intelligence to make good privates. About one per cent was graded as ' D — ' or ' E,' and was made up of men who could not rise above the third or fourth grade in school. They would be below the mental age of ten on the Binet scale. This classification assumes rather than proves the distribution according to the law of probability, but the assumption squares well with attainments in other lines and is at least not out of harmony with what we know in this and other connections.

The Coefficient of Correlation. — Any study of the causes of intelligence or of the way tests may be used for practical purposes compels us to make use of a statistical measure of relations between groups. The results in the army and since show that many men who stand high in the tests also make high grades in the universities. Were the relation direct, so that the man who stood first in the test always had the highest rank in college, and the man who stood second in the test stood second in college, there would be no question. But other factors come in. The naturally bright boy may be distracted by outside interests, or he may have bad health, or a number of circumstances may work together to reduce his success in collegiate grades. There is always a variability in grading which would introduce an error even were success altogether dependent upon intelligence.

A mathematical device for stating the relation between any two traits in groups is provided by the coefficients of correlation. In our case, it indicates by a number the probability that an individual who stands high in the test will also stand high in college. Were all individuals to hold the same rank in the mental test that they did in scholarship they would be said to have a coefficient of 1.0. Were the individuals who stood lowest in the test highest in their college grades, the coefficient would be − 1.0. Were there to be an entirely indifferent or chance relationship between the two series, the coefficient would be 0. Practically all show that there is a relation between two groups of measurements of this sort that is neither perfectly direct nor inverse. If the similarity is great, the coefficient might be between .80 and 1.0. A coefficient of 0.50 in unselected material would mean a considerable

degree of resemblance; less than 0.30 has little significance unless a number of measurements on different groups gives very nearly the same result, *i.e.* in technical terms, the probable error is very small. An illustration of the method of determining a coefficient of correlation is given in the footnote.[1]

Causes of Difference in Intelligence. — Armed with this instrument we may meet several questions concerning the interpretation of intelligence. The first is why are men

[1] Individuals	Scores in Arith.	Scores in Geom.	x = Diff. of Scores in Arith. from Aver.	y = Diff. of Scores in Geom. from Aver.	x^2	y^2	$x \cdot y$
1	70	55	− 14	− 19	196	361	+ 266
2	75	92	− 9	+ 18	81	324	− 162
3	80	60	− 4	− 14	16	196	+ 56
4	82	65	− 2	− 9	4	81	+ 18
5	84	50	0	− 24	0	576	0
6	85	65	+ 1	− 9	1	81	− 9
7	88	96	+ 4	+ 22	16	484	+ 88
8	88	87	+ 4	+ 13	16	169	+ 52
9	92	80	+ 8	+ 6	64	36	+ 48
10	96	90	+ 12	+ 16	144	256	+ 192
Average	84	74			538	2564	549

r = coefficient of correlation

Σ = sum

$$r = \frac{\Sigma x \cdot y}{\sqrt{\Sigma x^2 \cdot \Sigma y^2}} = \frac{549}{\sqrt{538 \times 2564}} = \frac{549}{1174.49} = .467\ (.47).$$

The calculation above shows how a coefficient of correlation is computed. This sample gives the relation between the standing in a course in geometry and the standing of the same individuals in arithmetic. The first column lists the individuals. The second column gives the actual grades in arithmetic, the third column the grades of the same individuals in a class in geometry. At the bottom of each column is the average. The fourth and fifth columns contain the deviation of each individual from the average with a minus sign when below the average and a plus sign when above the average, for arithmetic and geometry respectively. The sixth and seventh columns give the squares of the deviations in each subject. The eighth gives the products of the deviations from the average of the same individual in each subject. This respects signs. Where both are on the same side of the average, the product is positive, where one is above, the other below, the product is negative. The sum at the bottom of the column considers signs, so the more that are on the same side of the average, the larger the sum.

The computation is indicated below. The xy gives the numerator of the fraction, while the denominator is the square root of the product of the sum of the

different in mental capacity? Apparently the difference is very largely inherited. Karl Pearson long ago indicated that the coefficient of correlation for the intelligence of members of the same family is about 0.45 or about the same as for stature or for other physical characteristics. Goddard even found evidence that feeble-mindedness followed the Mendelian ratio about as accurately as do the characteristics of plants or animals. Terman showed that children chosen from the schools as superior in both tests and accomplishments had parents who were also of superior ability. Twins are more similar than ordinary brothers and sisters, but if different at birth do not become more alike as they grow older. Recent tests of foster children show that the intelligence of the child at maturity is slightly influenced by the intelligence of the couple who adopt him, but is nearer the level of his natural parents. If a child whose parents are of an average intelligence quotient of 1.00 is adopted by individuals whose intelligence quotient is 1.15, he will have a quotient of 1.04 in one set of experiments and of 1.07 in another. There is evidence that the results of tests depend in considerable part upon education and the change may be not in intelligence but in ability to pass the test as a result of better training. All the evidence that we possess indicates that intelligence is determined by heredity rather than by schooling or other forms of environmental influence. Accidents and ill health may reduce intelligence but nothing can increase it.

Intelligence and Success. — Evidence that the mental

squares. The denominator is constant, while the numerator varies with the similarity of the standing in the two subjects. Were the standing of the same individual exactly the same in the two subjects, xy would be equal to the sum of one set of squares, and the quotient would be one. The greater the departure from this similarity, the smaller is the fraction. It approaches zero as a limit.

tests actually measure a generally applicable capacity can be found in the distribution of test scores among the different callings represented in the army. Teachers, engineers, and lawyers stood at the top of the list, with unskilled labour at the bottom. The officers averaged much higher than the enlisted men, and the officers in the more skilled branches of the service stood higher than those of the line. The diagram (Fig. 47) shows the distribution of the men as a whole and of the officers and non-commissioned officers in accordance with their test scores. It shows that the distribution follows the curve of errors as was said above, and also that the officers are chosen from the superior men. The illiterate men also are unintelligent, as is shown by the fact that they are distributed about the lower end of the curve, even when measured by methods which do not employ words. Similar relations show themselves between ability to do well in college and standing in the tests. No man with a standing below a B grade can expect to succeed in college. Numerous tests show that there is a coefficient of correlation of 0.40–0.45 between standing in the army and similar tests and grades that are made in a college.

All Intelligence of the Same General Type. — The results of the different tests all agree in indicating that excellence in any desirable trait is closely correlated with excellence in all other desirable traits. Thus there is a positive correlation between memory and quickness in sorting the alphabet, between sorting cards and discriminating weights, in fact between all of the desirable qualities that have been carefully measured and compared. If we translate this statement into our everyday expression, the all-round man is the rule, the man of one-sided development, the exception.

More than this our present knowledge is not sufficient to show. Either the innate differences between types are not sufficiently marked, or the combinations of traits are so numerous and so many different arrangements result that we have not yet been able to discover and formulate even those occurring most frequently among them.

Character Closely Correlated with Intelligence. — The method of estimating the relative amounts of intellectual as opposed to emotional and voluntary traits possessed by different individuals was applied extensively by Webb.[1] He asked several instructors to grade a large number of boys with reference to the more characteristic intellectual traits, and also on a series of more general traits, 'tendency not to abandon tasks in the face of obstacles,' 'tendency not to abandon tasks from mere changeability,' 'kindness on principle,' 'trustworthiness,' 'conscientiousness,' 'readiness to become angry,' 'eagerness for admiration,' and 'bodily activity in the pursuit of pleasure.' When these were correlated with each other, it was found that the first five showed a high correlation, — an individual who was preëminent in one would be likely to be well favoured in the others also, while they showed a negative correlation with the last three. The last three also correlated closely with each other. Webb argued from these results that we must recognize two groups of traits, an intellectual and what he calls the character group, which depends upon what are popularly known as the volitional and emotional characteristics. The desirable traits in each are likely to be found together. Between the two groups the correlations are not so close as they are between traits within each group, but

[1] Edward Webb: "Character and Intelligence," *British Journal of Psychology*, Monograph Supplements, III.

even here the more desirable characteristics show some correlation. On the whole the man with the better intelligence is also the better tempered and has the better qualities of leadership and persistence.

Interpretation of Results. — Both methods seem to be at one in the positive statement that excellences in all desirable respects tend to be found together. How this shall be interpreted is not quite so clear. It may be due to the presence of some common quality in all mental operations, possessed by each individual in varying degrees. As will be seen in the next chapter, Spearman has suggested that we must assume the existence of a general intelligence, and that an individual who has much of it will show all desirable traits in high degree. Its possession makes all accomplishment easy, its absence reduces capacity in any field. The other alternative explanation would assume a number of traits which are required for success in each of the tests. Thus, if we assume a native retentiveness, acuity of the different senses, quickness of reviving associates, and motor quickness as fundamental traits, such a test as marking the a's on a page of print might involve at least three, probably four, and almost any other tests that might be given would employ more than one.

Specific Factors in Intelligence. — Unfortunately thorough analysis of the elements that enter to produce high scores are still largely lacking. Travis and Hunter and Rounds have independently found recently that mere quickness of the passage of impulses in the nervous system is closely correlated with intelligence. Peaks and Boring showed a similar high correlation between reaction time and intelligence. The correlations are higher than those

between intelligence tests themselves, which looks a little too good to be true. Similarly Slater, working with young children in an investigation as yet unpublished, showed a very high correlation between ability to learn geometrical figures and intelligence. Hegge found a similar high correlation in feeble-minded individuals between learning meaningful material and intelligence tests. If we take the results at face value, it would seem on the one hand that intelligence is entirely a matter of the speed with which nerve impulses pass through the nerve. If we consider the other similarly, it would seem that what we measure in intelligence tests at least is merely the capacity to retain simple material. Against the assumption that memory alone would be sufficient for intelligence is the fact that several of the memory prodigies have had a low intelligence as measured by success in life or by formal tests. It is probable that similar investigations would make possible an analysis of the general character of intelligence into a number of subordinate elements. At present these results stand as indicative of a method, and as showing two important components.

Are There Different Types of Men? — As to how far we may distinguish between what for convenience are called the intellectual and the voluntary and emotional characteristics which combine to give what we ordinarily call character, we have less evidence. Webb's results stand almost alone. They would indicate that part of a man's success would depend upon intelligence, part upon pertinacity as opposed to a tendency to be guided by desire or pleasure. Popular observation indicates that man's effectiveness depends in part upon pure intellectual capacity and in part upon the use that he makes of his ability, includ-

ing his willingness to exert himself to learn and apply his knowledge and the positiveness with which he expresses his conclusions. In the estimates of an officer's ability on the personnel card used during the war, there was a place for an estimate of personality which includes leadership and tact, qualities which would come under our emotional and voluntary traits. These are accepted as quite as important for success as intelligence. One may fail for lack of either. Mrs. Woolley found that these volitional and emotional traits were almost as important as intelligence, as determined by test, in deciding what wages would be earned by children who leave the public schools. These qualities are fairly closely correlated with intelligence according to all tests. This is what would be expected from the fact that appreciation of the ends of life and of the necessity for endeavour to attain them is a large element in keeping a man at work.

Intelligence and Mechanical Abilities. — Important for practice is the relation between mechanical skill and intelligence. These seem in general to be independent. The authorities of dental colleges find not infrequently that men who have a high standing in the scientific and theoretical courses of the first years cannot develop sufficient skill in the operative work to become dentists. Mrs. Woolley also found that school children with considerable intelligence might stand low in mechanical tests. On the other hand more than a minimum of intelligence is needed for mechanical operations. In one large industrial plant, many accidents were prevented by giving mental tests to applicants for employment and eliminating those persons who stood low. Intelligence and mechanical ability appear to be but slightly related.

The Lower Grades of Intelligence. — The different methods of testing intelligence have been applied with much success in measuring the abilities of children in the schools and in connection with the courts in deciding upon the methods of treating those who become social problems. For convenience in nomenclature Binet suggested that one could make a classification into three groups on the basis of these age determinations. Individuals of a mental age of two or less are called idiots, those of a mental age between two and seven are called imbeciles, and those from eight to twelve are called morons from the Greek word for fool. In terms of I.Q., an idiot has an intelligence quotient below 25, an imbecile below 50, and a moron between 50 and 70. Idiots are incapable of living without constant attention; imbeciles require institutional care in practically every case, but can satisfy their own physical needs, while morons may seem normal or merely dumb-witted but cannot compete on equal terms in the struggle for existence and are often a menace to society by lack of self-restraint. They constitute a large percentage of the lower classes of the community.

The Problem of the Feeble-minded. — It is estimated that from one-half to one per cent of the population is found in the three classes of defectives. In the army tests of a little more than a million men more than 16,000 had a mental age of eight or less, and more than 7000 of less than seven. Of course the more obvious cases had been sent to institutions earlier or were rejected by the examining physicians. The mentally deficient individuals constitute a permanent problem for the schools and for the courts. Many of the children who are repeatedly falling behind in the schools prove on test to belong to the feebly endowed. They cannot learn the ordinary materials or by the methods

of the normal children. If they are to be taught they must be given special training and in many cases can learn to advantage only the more mechanical operations. Many of these children pass from the schools to become ne'er-do-wells and paupers. The lowest in intelligence must be cared for in institutions, the others need constant oversight. The inmates of poor houses and certain reform schools show on test an undue proportion of the poorly endowed mentally. It is often said that the criminal class, too, is largely made up of the moron type, but recent tests of the inmates of penitentiaries show a distribution of intelligence not much different from the average. Apparently one must look to more positive types of abnormality and to defects in the volitional and emotional equipment, together with bad training, for the explanation of many types of criminality. As many of the feeble-minded are descended from individuals themselves feeble-minded, it is probable that the condition is inherited in most cases and that all that can be done to improve the situation is to keep them in institutions, — if possible in institutions where work may be provided that will make them self-supporting, — where they may be kept from harming themselves and others, and prevented from propagating their kind. A proper solution of the problem of caring for them will have a marked beneficial influence upon the state in relieving the schools and preventing crime and pauperism.

The Higher Grades of Intelligence. — Probably it is just as important that the superior individuals should be selected and given special treatment. They are likely to be permitted to waste their time in the schools by keeping step with the average child. Studies by Terman and others indicate that some two to five per cent of the school popu-

lation might well be put in a group by themselves and permitted to advance as rapidly as they can. They should also be kept sight of in the higher institutions that they may have an opportunity to reach the positions where they can make use of their superior ability. They receive less attention than the sub-normal group because they are never problems. Within limits they can take care of themselves. If they happen not to be given suitable training, a possible leader is lost from some field. As there is always need of leaders in every field, the loss is irreparable.

Are There Special Types? — If we return to our original question as to whether we have special types of ability, our answer must be on the whole a negative one. Intelligence seems to be all of one kind. A superior man in one department of life would have been superior in any other in which he might happen to have been trained. This conclusion is confirmed by observations and statistics of actual accomplishment as well as by the results of tests. Comparison of grades of individuals in grammar school, high school, and university shows that students with a high standing in one have a high standing in others also. This correlation holds between school standing and accomplishment in later life. A man who stands high in his university class has a much greater chance of obtaining eminence than the man of average rank. A man who has been elected to the honorary society of Phi Beta Kappa, election given to the men among the upper fifth of the class at graduation, is four or five times as likely to appear in "Who's Who" as are his classmates of lower standing. Studies of the salaries of graduates of an engineering school some years after graduation showed that there was a close correlation between salaries received and standing while in college. The

statement that ability is not specialized is strikingly confirmed by the fact that high standing in the undergraduate college in Harvard College foreshadows success in the medical or law school of the university, whether the subjects studied are or are not closely connected with the later work. We have also seen that while the desirable degrees of voluntary and emotional characteristics may vary independently of ability in some degree, on the whole the differences are not great enough or sufficiently marked off into groups to be certain that they constitute types. They vary independently, but always by slight changes, never by large jumps.

While we cannot emphasize too strongly this general statement that ability is all of one kind, it is at the same time well to admit that denial of a specialized ability rests upon negative grounds alone, that it is safer to say that we have not yet discovered different types of mind than to assert that they do not exist. Certainly in everyday life we find men who succeed in business who did not do well in the university, and men who do very well in specialized professions who were of only moderate ability in the professional school. They will not infrequently win fame where their fellow of higher standing is only moderately successful. These cases may be explained in two ways. In the first place, our general statements hold only in the long run and on the average. Many exceptions are admitted in the averages. These are lost in the general statement, are outweighed by the great majority, while just because they are exceptions they are likely to attract the ordinary observer. In the second place, the differences may be due to training. The general belief in types may thus be due to mistaking the exception for the rule, it may be due to mistaking success due to special training or to special

opportunity for success due to special aptitude, or it may be due to failure on the part of psychologists to devise tests that will discover special aptitudes, and lack of investigations of the ways in which they may be combined. It is altogether possible that the relatively few studies published have not happened to hit upon the proper methods or have not been sufficiently detailed to discover differences which may be slight and still in the main constitute types of intellect. Certain it is that popular belief in the existence of groups of traits in individuals that constitute them distinct types is strong, and one cannot be equally certain that the psychological studies are sufficiently advanced to dispute this belief.

Not Types but Variations in the Mass. — On the whole it seems, then, that we may feel fairly well assured that all forms of excellence in mental capacity are closely correlated, that a man who stands well in one capacity is likely to stand well in all. That there are numerous differences in the grades of accomplishment in different lines is equally certain. So far, however, we are not able to sort forms of capacities into distinct groups. There probably are many of these types, — certainly no two men are alike in all particulars, — how many we are simply not able to say. Furthermore we cannot say to what these differences are due, whether to differences in native endowment, to differences in training, or to opportunity. In this sense the psychology of mental types or of individual differences is yet to be written.

QUESTIONS

1. What do you mean by intelligence?

2. Is it possible for a student with an I.Q. of .80 to make an A grade in psychology by hard work?

3. How can you measure mental age?

4. How does the measurement of intelligence by the Army test differ from that of the Binet test?

5. If there is a coefficient of correlation of .50 between a mental test and a grade received in college, would the test be useful to decide who should be admitted?

6. Is there any similarity between standing in mental tests and estimated good temper?

7. What is the average intelligence of criminals? of paupers?

8. What is the average intelligence of the general population in mental age? in standing on the Army tests? How does it compare with the intelligence of the college student?

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CHAPTER XVI

THE INTERRELATIONS OF MENTAL FUNCTIONS

Criticism of Faculty Psychology. — For the sake of convenience we have been treating the mental operations separately and may have left the impression that each of the names used stands for a separate function or thing. This was in some degree the assumption of the older psychologies and still is the prevailing popular belief. We have spoken of attention and of memory and of other processes because they represent mental capacities which it is desirable to discuss together. The popular mind always finds it easy to put a thing behind the function and to speak of *the* memory, *the* will, and so on, as if they were separate entities or forces. In the very early psychologies, these functions were personified and the older men were inclined to speak as if mind were a partnership in which each partner had separate abilities and capacities, and as if these capacities were practically independent one of the other. In the discussions of modern psychology there is no such implication. The words stand for nothing but observed facts, — the fact that one remembers, that one acts and makes decisions, or that one attends. What may be behind the activity we do not pretend to know, but we certainly do not care to assert that any 'thing' is behind any act or activity.

The Transfer of Training. — One problem of considerable practical importance is the degree of relationship and the

mutual dependence of the different capacities. In connection with training it is interesting to know if one may train a capacity by training some other capacity, or how far training in one field may be helpful in some other. The theoretical considerations may give any conclusion indifferently, and popular opinion seems to be much divided as to how far the effects of training may spread from the function actually exercised to other related functions. There is also equal difference of opinion as to what are related functions and how they may be trained. Two opposing general principles are currently accepted and serve as a basis for popular opinion. On the one hand, the separate functions have been regarded as absolutely distinct; on the other, any training is assumed to be effective for all mental capacities. Obviously with such wide diversity in general theory, there is a necessity for appeal to closer analysis and, if possible, to actual trial.

The Primary Functions of Mind. — Our earlier analysis has shown that the different functions have much in common. The fact that impressions are retained is fundamental, not for an explanation of memory only, but for the control of attention and action and almost everything else. Earlier experiences must give the materials of reasoning as well as aid in the control of the reasoning operations. A complete analysis shows that much the same processes are fundamental for all the cognitive operations, and for many of the feeling and active processes. These are the facts of sensation, of retention and recall, and of selection and control. These, together with the complementary processes of recognition, belief, instinct, and feeling, suffice to explain all the functions of consciousness. Perception depends upon the control of the entering sensa-

tion plus the recall of related and interpreting elements which, in their turn, are selected to harmonize with the general setting, objective and subjective. For example, one comes into a furnished room tired, and accordingly a chair catches the attention. This perception involves a rhomboid of colour upon the retina; earlier experiences lead us to transform the rhomboid into a square surface; replace acute and obtuse angles by right angles, and so on. We have a combination of sensations and memories, controlled by the needs of the moment, a process we call perception. Similarly one comes into a bare room, feels tired, and the sensations with the general setting call out the memory of a chair, perhaps of the same chair. We call this process memory or imagination according as the recalled chair is familiar or unfamiliar. The only appreciable difference in the two processes is the presence in perception of the rhomboid of colour upon the retina.

Action Involves Sensations. — Again the memory of the chair may start a train of movements that sends one into the next room for a chair or to the telephone to order one seen in a shop window an hour before. We call this will, but it is different from memory only in that the associated movements are permitted to run their course, — again under the control of the purpose and knowledge of one's credit at the shop and the permanence of the need. This difference is even less when one considers that every memory and every perception tends to call out movements of some sort, and that what really distinguishes them from will is the degree or amount of the movement, not its presence or absence. In memory or perception the motor discharge ends in slight movements, while in will the movements overshadow all else. Any of the other functions ordinarily

given distinct names may be regarded as differently compounded out of the same elements. The combinations alone are different; the elements and the conditions that control the selection are largely the same in each. It is to be expected that any change in any function will affect in some degree each of the other functions. Either it will supply new materials that may enter into other functions, or will change the conditions that control the selection and arrangement of the materials.

Names of Processes Are of Functions, Not Entities. — Not alone are the different functions interrelated as different expressions or combinations of the same mental materials and laws, but in any single act each is likely to be involved in some degree. One turns in quick succession from memory to action, from reasoning to imagination, and then to perception, and each is distinguishable from the others only by abstract analysis. The separate functions are really not more separated than are different applications or uses of the same function. The memory employed in learning nonsense syllables is more different from that used in learning historical events in their logical succession than is the latter from the reasoning employed in reconstructing some partly forgotten event on the basis of its remembered antecedents. The first two are certainly memory, the latter is just as certainly reason. What is different and what marks the lines of division in consciousness are the uses to which certain processes are put. The processes receive names that correspond to the uses, even when the elements or conditions are essentially the same.

Transfer of Training. — The problem of how far training may spread must be attacked by experiment and observation. Nothing in the nature of mental capacities gives

certainty that training may not spread from one function to another, and nothing indicates that training in one field has any particular amount of influence in any other. All that can be said on general principles is that where two functions have something in common, training in one will probably have an effect upon the other; where there is nothing in common, training in one capacity will be without influence upon the other. On purely theoretical grounds one would expect that use anywhere either would provide new materials or would add new elements of control that might be used in any other field. If one asks whether attention to the endings of Latin verbs will increase the capacity of the individual to detect new species of mushrooms, one can answer only by trying the experiment. The fact that both processes are called attention does not of itself prove that training one will improve the other.

Can Memory Be Trained? — For an answer to our question we must turn to an examination of the results of experiments, — first of the effects of training one function upon other expressions of the same function, and second upon the transfer of training from one function to another. The field that has been best developed is memory. It has long been a question whether it is possible to train one's capacity to remember facts of one sort by practice in learning some other set of facts. The first answer to this question in more recent times was a decided negative. James argued that in learning one statement a different tract in the cortex must be involved from that involved in learning any other, and consequently training one nerve tract would have no more effect upon another tract than would practice in bending a finger upon the ability to walk. James also put the opinion to practical proof by learning a bit of verse,

then spending a month in practice on other poetry, and testing the efficiency acquired by learning other stanzas of the test material. He found, on the average, that there was little if any gain after the long training, and concluded that memory cannot be trained.

More recent tests by Ebert and Meumann came to the opposite conclusion. They worked with various sorts of sense and nonsense material. First, the untrained capacity was tested for one sort of material; then a long period was devoted to learning materials of another kind. Then the first sort of material was learned again and the ease of learning after practice was compared with the original. Other practice series were made and again tested. The results showed that practice with nonsense syllables would increase the ease of learning philosophical prose or arbitrary visual signs by from 50 to 70 per cent. They concluded that learning anywhere will increase the efficiency of memory everywhere, that practice in learning material of any one kind will have a marked effect on learning any other. The conclusion has been criticized on the ground that the test series for each sort of material were so long that there was considerable opportunity for training in the tests themselves.

Dearborn repeated the experiments, except that he had two sets of workers. The one group followed Meumann's procedure: found how many repetitions were needed for learning poetry, for example, then practiced learning nonsense material, and went back to see if that training had any effect upon the repetitions required for learning a similar bit of poetry. Another group learned the same poetry, and did not take the training on nonsense syllables, but were tested for learning poetry after the same interval

as the others. The second test of these untrained subjects showed an improvement over the first, but a slighter one than did the second test of the group who practised on nonsense material. The results indicate that the training has some effect but not nearly so much as Ebert and Meumann thought. Probably the effect of training in one field upon learning in another will amount to from 10 to 20 per cent as compared with the 50 or more that Ebert and Meumann's experiments indicated.

Improvement in Memory, Improvement of Method. — Woodrow has found that much more improvement is made if the learners are informed at the beginning of the best methods of memorizing. He divided students into three groups. One was a control group, another the practice group as with Dearborn. For the third he spent seven minutes of each twenty given to the tasks in telling them the best ways of learning. They were advised to learn as a whole, to make frequent active tests, to look for meaning, and the other laws laid down in our chapter on learning. He found that these improved most of all. Their gain varied from 12.8 to 87 per cent as a result of about three hours' practice, while the practice group, who spent the same amount of time, but spent all of it in practice, improved only from 3 to 37 per cent. The improvement is apparently due to hitting upon new methods of work and, if these are taught directly, much more improvement is made than if the student is left to hit upon them by chance.

Training Memory, Training Attention. — If one asks how learning one thing can have an effect upon learning something else in spite of the fact that the nervous structures involved must be different in each, the answer undoubtedly is to be found in the fact that learning of any kind involves

many common factors. One must always attend to the material learned, and in the experiments in question, one must learn to attend under new and unusual conditions and to materials that one usually has tried to neglect. The formation of habits of attending in general and of attending to unusual materials and under unusual conditions is the element that serves to make all learning easier. In the learning of everyday life still other common factors must be recognized. There are many structural elements in common between things and even between sciences called by different names. The same fact is used in different connections, and the resulting compound is given a different name in each connection. For example, the principles of history are frequently similar to the laws of biology, and the spirit and attitude are very similar in all sciences. All these facts and principles learned in one field save time and work in other fields. The improvement in one sort of memory, acquired by training some other, does not depend upon the training of some single function or thing, but is due to the fact that learning anything develops habits of attending and accustoms one to learn new materials and under new conditions. What is trained is some common function, not memory in general.

Transfer of Training in Discrimination. — Very much the same result has been obtained in experiments for training discrimination. It has been shown by Coover and Angell that discrimination for visual stimuli is improved by training in the discrimination of sounds, and the quickness of response in one way to one sort of stimulus is increased by training in another form of response to another stimulus. The effects of the training again may be traced to the improvement in some capacity common to the two activi-

ties. Wang found that practice in discriminating the length of lines increased the ability to discriminate colours and tones. Measurements of the time required to make the comparisons showed that the child learned in the first tests not to speak until he was sure of his decision, an acquisition that proved valuable in the later tests. Training in the control of movement shows the same transfer from one field to another, as is demonstrated for these more intellectual capacities and activities. One may conclude in general that exercise of one sort tends ordinarily to improvement of related capacities. This rule is not without exceptions, for training may make learning more difficult under other circumstances and for certain sorts of activities, even if they bear the same name. An instance of this was cited in the chapter on memory. Common observation indicates that training in rote memory is likely to interfere with skill in remembering ideas, in logical memory; and *vice versa*, skill in remembering ideas may make one neglect the words and so make one learn them less easily than would the untrained individual. The explanation reduces to the same law as before. What is trained is a habit of attending, and attending in one way tends to prevent attending in opposed ways. Whether training is harmful or beneficial depends upon whether some habit is common to the two processes under discussion, or whether a habit established in one operation will be injurious in the other. One can assert at present only that whether training in one act or in one field will be beneficial to other different acts or in other fields depends upon whether the two functions have anything in common, and whether the common factor works in the same way in each of the activities in question.

Training of General Intelligence. — Still more com-

plicated is the problem and less definite the result, when one turns to the question whether there is anything in common between functions or capacities not of the same general kind. One of the best-known theories asserts that a definite relation does exist between skill in any field and the general intelligence of the subject. It is insisted that all capacities are sufficiently interrelated to have skill in one involve skill in any other. The facts upon which this theory, suggested by Spearman, rests, are now generally accepted as a result of agreement in the outcome of numerous investigations. However, many, if not most, question the theory, which smacks of faculty psychology. Instead it is suggested that common capacities are involved in many seemingly different operations. The improvement in one, as a consequence of training in another, rests upon use in both of a single capacity. At least fact and theory agree that it is possible that training will have some effect upon capacities that have something in common, but whether much or little can be determined only by experiment, and satisfactory experiments are as yet lacking.

Training from Subjects of School Curriculum. — Still farther are we from being able to assert that certain subjects in the school curriculum will have an effect upon any particular capacity, or that one subject will have a greater effect than any other. It is frequently asserted that mathematics trains reasoning; classics, memory, and so on. These assertions are based altogether on assumption and apparently assume an out-of-date psychology. Certainly few experiments have been performed and no tests of the effects of studying one subject apart from others have extended over a sufficiently long time to give trustworthy results. From general considerations it is evident that the

results of studying any subject will depend in very large degree upon how it is studied and how it is taught. Mathematics may be made a mere exercise in memory, while history or the classics, when studied by suitable methods, may be primarily training in reasoning. The most that may be said with certainty is that the sort of training derived from any subject will depend more upon the way it is taught than upon the subject. Any subject may give any type of training, and probably all forms in some degree, but how much depends upon circumstances that cannot be determined from the name of the subject. At present it is not possible to say how far any activity may be prepared for by any subject in the curriculum.

Summary. — We have one very general conclusion from the studies so far made concerning the possibilities of training. If you acquire skill in doing any one thing, you can do better anything else that involves the same capacities. However, we have still a very limited knowledge as to the overlapping of these capacities. No two acts are exactly the same even if they go by the same name. On the other hand, acts which seem to be altogether different may have common factors. Each activity, mental or physical, has a marked effect in improving the capacity for doing that one thing, and a slighter general effect which increases ability to do other things that have less in common with it. Only experiment can determine whether one type of training will aid in doing anything else. There may be some effect or there may be none, according to the relation of the two functions. There is little evidence of any single function or faculty, like general intelligence, that may be developed by all sorts of training and be applicable in all fields. The most that can be said positively is that one may best prepare

one's self to do anything by doing that thing. It does not follow that doing that thing will be the best preparation for life, or for success in any other capacity, but certainly skill in that function can be most surely acquired by practicing it directly. A general training is indispensable, not because it gives command of a particular trade or profession, but because anything can be understood fully only in terms of other things, and because highest success is possible only when preparation has been, not for one task alone, but for many tasks of a related kind, — for all, in fact, that have any bearing upon the chosen career. The main outcome is to enforce conservatism in asserting just how best to obtain a general training. The one assured result is that training for any particular task or operation can be acquired by doing that particular thing.

If the discussion has served to emphasize the fact that, on the one hand, mind is not a collection of unrelated faculties and, on the other, that it is not a single force or faculty, but rather that mind is merely a term applied to a number of different functions spoken of collectively, the time will have been well spent. When certain of these separate functions are grouped in one way or to the attainment of one end, the process is called perception; when grouped in another way, imagination; in a third, memory; and in a fourth, reasoning. When other functions are introduced and practical activities are controlled, the process is will. Other modifications constitute the emotional and affective processes. In any event, what gives the name to the function in everyday life and in scientific usage is not the materials of which the mental state is composed or even the laws revealed in its operation, but the end that the function subserves. The fundamental laws of operation and the

simple elements are relatively few as compared with the ends and the names for functions or 'faculties,' either popular or scientific. The division of the treatment of psychology into chapters devoted to these particular functions is for convenience. The functions themselves are not distinct.

QUESTIONS

1. What is meant by a faculty in psychology? State objections to the use of the term.

2. Define mental function. How many mental functions would you ascribe to man? How is a function different from a faculty?

3. Can you train will? In what sense do you use the term in your answer?

4. Outline the evidence for and against the possibility of improving the ability to learn. Is it a faculty, or merely a method, that is improved?

5. Would training in recognizing flowers make one more accurate in recognizing animals? What would you assume in your answer concerning partial identity of the functions involved?

6. What could one mean by general intelligence? Can it be trained if it exists?

7. What training do you expect from mathematics? from history? from Latin? from physics? from psychology? Would it be more in any case than the accumulation of facts? What changes might be common to all?

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CHAPTER XVII

THE SELF

THE last problem, the nature of the self, the 'I,' is fundamental. Throughout the book, we have been asking what man can do and what his mental processes are and what they mean. Now we raise the more general question, what is it that makes the self, and how is the self known? Much of the discussion of the nature of the self in philosophy and in popular thought and conversation has little to do with psychology. On many of these problems the opinion of the psychologist is little if any more valuable than that of the untrained layman. Certain phases of the problem of the self are of a psychological character, however, and consideration of them is not only important for itself, but serves to give a review in perspective of many of the more concrete discussions. Without prejudice to the problems that lie beyond the range of psychology, we speak from the standpoint of the psychologist.

The Content of the Idea of the Self. — The self may be approached from two distinct sides. One may ask what is in mind when one thinks 'I.' This question is on the same level as any other concerning the nature of a mental state; it is a question of structure. Questions of the other type deal with the capabilities of the man; they ask what the self does in different relations, they raise problems of function. The first problem is of what the man appreciates as himself. The other asks what it is that makes an observer

regard the man as continuously the same person, why he is trusted to act in a definite way, at all times. The first constitutes the phenomenal self. The last the active self. The problems are different, although closely related. What one accomplishes colours one's idea as to what one is, and, conversely, what one thinks one's self to be has a considerable effect in determining what one can accomplish. For our purposes, the first is the problem of the self as viewed from within, the other the problem of the self as it presents itself to the onlooker.

The idea that is in consciousness when one thinks 'I' varies from moment to moment and from individual to individual. It has been suggested that it is made up in part of the mirror images of one's self, in part of the framework of nose and eyebrows through which one views the world, and of the constant background of tactual and organic sensations. Probably some of these elements may be present in the idea of the self, and each has, at some time or other, helped to make the individual acquainted with himself. The most prominent group of elements in the total picture is the mass of organic sensations. They are always present, although they vary in quality, and probably always colour the mental life. When 'I' feel ill, they are of one sort; when 'I' feel well, they are of another character. In either case, ill-being or well-being is appreciated through them. The importance of these organic sensations has been emphasized by the fact that in certain cases, loss of appreciation of self-identity seems to depend upon a transformation of the organic sensations. The individual whose permanent sensations have undergone a change, no longer feels himself. It seems likely when a patient in delirium seems to be watching himself from above or from somewhere

else outside of his body, that the disease processes have changed these sensations, and the man no longer recognizes himself. These sensations constitute only a part of the idea of the self regarded as content. One must add the social elements in the idea that are probably even more important. It is not so much how one actually does appear, as how one thinks one appears to others that constitutes the notion of the self. In this idea, as James points out, a large place is taken by external belongings, clothing, automobiles, bank account, and possessions of all sorts. One grows with one's goods, and even with one's friends and the circle of acquaintances. But while all of these elements serve to give tone to the idea of the self, that idea itself is a concept developed through the experience of the individual to represent and, in part, to account for himself. Like all concepts, the content may vary greatly; but the thing represented is more fixed, although that, too, is subject to constant change with growth and with the phases of experience that it represents.

The Active Self. — The treatment of the active self offers more difficulties. The idea of the self as an agent has developed to explain the unity and continuity of conscious processes in any individual, and to make the consistency of the different acts of the same man conceivable. If consciousness were merely a mass of states, an individual's experience would not be regarded as continuous, as parts of a single whole, but would be a mere jumble of separate events or things. Even the mental states of any moment would be only separate states, it has been asserted, unless they were held together in some way. The concept of the self has been developed popularly and philosophically to make conceivable the facts that mental states do

constitute a unity, and that all states of whatever period are regarded as *my* states. The facts implied by the term self are that the different experiences are parts of a single whole which persists from life to death, and that the thoughts of any moment constitute a unity. More practical is the problem as it presents itself to the friend or business associate. This is, why does the same man act in approximately the same way toward the same situations, and why are his methods of action peculiar to himself? When a man makes a sudden change in his course of action, it is at once said that he is no longer himself. The facts to be explained in connection with the self are first, the continuity of conscious states; second, the unity of consciousness at any moment; and third, the self-consistency of action.

The Self as Accumulated Habits. — One of the most superficial explanations of the consistency of action from moment to moment is to be found in the persistence of habitual responses. In considerable degree, it is possible to read character from the face. So far as this is possible at all, it is, as was said in an earlier chapter, because the face retains the imprint of the earlier expressions of emotions and of feelings. Every thought and feeling induces some contraction of the facial muscles, and each of these contractions leaves its impress on the face by enlarging the muscle or by wrinkling the skin. Thus old expressions and indirectly old experiences write their record on the face for him who runs to read. But these same experiences induce habits, not merely in the facial muscles, but in all parts of the psycho-physical organism; in consequence, even the most general mental and physical responses and attitudes correspond to the configuration of the face. Both have

been developed in the same way. In truth, very many of the subtle peculiarities, which together constitute character, are traceable to habits. Much of good temper or bad temper is dependent upon the habit of smiling or of scowling, upon the habit of sharp speech or of mild speech. Whether the first and natural attitude toward a situation is of pleased acquiescence or of fault-finding is very largely a matter of habit. Even the moral elements of character have their habitual constituents. One has habits of honesty and punctuality in meeting obligations, just as one has habits of rising or of eating. It is as difficult to break a habit of paying bills at the end of the month as a habit of late rising. Bad habits in morals may reach the point where they are as difficult to break as a drug habit, where all the consequences of the acts are neglected. At this stage, the man has become an habitual criminal, and self-restraint must give way to restraint by others. A self of one sort may become altogether changed in the course of a few years, merely through the development of a new set of habits. The self from this simple point of view is in great part merely the accumulation of habits, the outcome of the earlier actions of the individual.

The Self as an Expression of Organized Experience. — Still more intimately connected with the development of the self and self-control is the effect of earlier experiences as they are expressed in present experience. Throughout our treatment of the earlier topics, particularly in connection with reasoning and action, we have had occasion to emphasize the importance of the system of knowledge and the system of purposes. It has been pointed out that attention, perception, memory, and action in all of the higher forms are controlled by earlier experiences, not as

single and sporadic elements, but as organized systems. Practically all of the important functions ascribed to the self are, when examined critically, seen to be due to the action of earlier experience. What makes one man different from any other is that he sees differently, thinks differently, and acts differently. These depend upon the actual knowledge that he has accumulated, upon the associations and habits that he has developed, but, above and beyond that, upon the control of organized knowledge and upon developed purposes.

The individual starts life with certain tendencies that are a part of the common racial inheritance. The early self, so far as one may speak of the infant as having a self, is dependent upon these instincts for its character. As he grows, these are first modified by experience, then experiences become the dominating factors in determining the nature of the responses, mental and physical. There is seldom a complete and sudden change in the character. It is only gradually that the original instinctive character is modified by experience; the single experiences in the later stages work but a comparatively slight change. The original kernel of the self constantly grows and expands by taking up into itself new bits of knowledge. As Tennyson sings in his 'Ulysses,' 'I am a part of all that I have seen.' Ordinarily it takes years to make a marked difference. The self of to-day is not noticeably different from the self of yesterday, although it is markedly different from the self of twenty years ago.

Changes in Self through Experience. — Occasionally one will see a sudden 'about-face' in a character. Instances of sudden conversion may be cited. Some striking event seems to throw new light on the relation of the individual

to the world and his fellows, and his entire attitude changes, and with that his actions. Sometimes a sudden misfortune will destroy the confidence built up through a lifetime of successful activity. The resolute, self reliant man of affairs becomes hesitant, dependent, and loses all initiative; he becomes a human derelict who cannot be relied upon for even the simplest tasks. Such sudden changes are the exception; usually character is of slow growth and the changes can be detected only after the lapse of years. The individual peculiarities and the consistency of action that mark the self depend in part upon the habits, and in part upon the control exerted by the accumulated experiences and purposes upon thought and action.

The Self as a Continuous Existence. — The second function or characteristic of the self is to explain the fact that all mental states are regarded as belonging together. This depends in part at least upon the continuity of memory. Professor James has asserted that what makes the self continuous is that one mental state always laps over upon the next. There are no blank spaces that separate one process from another. At any moment, several ideas are represented at different stages of development or disappearance. Other factors are found in the persistence of memories, and in recognition. The self probably is recognized in very much the same way as any object. The older experiences interpret the new. Recognition of objects, as well as the recognition of the self, serves to prove the continuous identity of the train of experiences. To these must be added the fact of the return of old memories, and the anticipation of future events in the light of the past. When these anticipations are confirmed by actual experiences, the new is more firmly bound to the old and the old to the

new. That one is constantly looking forward and backward from the present and, particularly, that the past anticipations are confirmed by the events of the present, serve to bind past, present, and future into a single whole. The continuity of reference, the development of types and meanings, and the confirmation or partial modification of the meaning of one time by the meaning of the next, all contribute their share to establishing the belief that the self persists.

The Self as the Unity of Experience. — To say that the self of any moment is a unit means merely that the component elements, in addition to being controlled and subordinated to the whole, must all be connected, and each must add its share to the whole. As was said in the second chapter, the consciousness of any moment corresponds to the action of many different nerve units in many different parts of the cortex, but to be conscious, any one of these elements must be connected with all of the others active at the time. To be conscious and to belong to the unity of the self are synonymous. This mass of mental states not only belongs together, but acts as a unit in the control of all subordinate mental activities. No experience is ever of discrete units, nor is any single process alone effective in determining the course of mental or physical activity. This interconnection, at once passive and active, is the basis of the unity of the self at any moment. One often speaks of the unconscious or the subconscious, as if there were a consciousness detached from the main or dominant consciousness, separated from the unity that has just been mentioned. It is true that movements are often made without consciousness, and still seem to be controlled by purposes. There are other instances in which all or part of

a course of thought shows characteristics of purpose that might have been developed by conscious states, but in which there is no evidence of consciousness. In all of these cases it is probably safer to assume that the determinants are physiological or nervous, rather than conscious. Surely the only safe evidence of consciousness is consciousness itself. An unconscious conscious state is a contradiction in terms.

The Controlling Experiences of the Active Self Not Necessarily Conscious. — It does not at all follow that because the self is the expression of the experiences from birth to the present that one is aware of these experiences at the time of the action. They act through modifications of the nervous system, that are retained as mere tendencies to respond or to start associations. The individual who is constituted of and controlled by them is no more aware of them than he is of the effects of experiences that determine his attitude in attention or the meaning of a word in thinking. He is aware of the result at times, although even that in action he may know only indirectly. He is not aware of the special experiences or of their effects upon his nervous system that compel him to do what he does or to think as he does. In this we must distinguish between the phenomenal self, discussed earlier in the chapter, and the active self. The phenomenal self of which we are directly aware covers but a fraction of the factors that control the active self. Even the awareness that we have is merely based upon the directing forces in the latter and does not involve an awareness at the time of the actual experiences that make it possible.

Dissociated Selves. — The consistency of thought and act that marks the man as peculiarly himself, the persistence

of self-appreciation from day to day, and the momentary unity of experience, each goes back for its explanation to the fact that all the accumulated experiences of the individual are combined into a single whole through the manifold interconnections of the parts. These interconnections give meaning to the different parts, and serve to direct and coördinate the various activities. That these relations and factors are actual, not hypothetical, is demonstrated by the numerous cases of dissociation of the self, in which the continuity of thought and action is broken. An individual who is dominated at certain times by one set of purposes and ideals will, at other times, be dominated by other purposes and ideals. At the instant of change, there will also be a break in the continuity of memory, and a transformation in the attitude toward conventional and moral restraints. The individual will carry on the ordinary routine life until some emotional shock or injury is suffered. Then all memory of the past will be lost; he will start up with no remembrance of his surroundings; in some cases, with no appreciation of any of the things about, and none of his accumulated knowledge.

Alternating Personalities. — In certain cases, the selves alternate. One self with its peculiar memories and characteristic actions and feelings will be dominant for a time, and the individual will have one set of memories, one emotional attitude toward the world; then suddenly the other will get the upper hand, all memories acquired by the earlier self will be forgotten, and the entire character of the individual will change. One of the earlier cases reported was of a woman, Felida X, who in the one self was moody and bad tempered; when the other self came, she would be cheerful, a more capable worker, and different in every

respect from the first. These states alternated for a period of thirty years or more. They would be separated by a period of unconsciousness at times, and at times the change from one to the other would be sudden and with but slight warning. After the change, the immediately preceding events would not be remembered. Later, when Felida had come to know the symptoms of the change, she would write down the things she would need to know in the approaching state. She was a small shopkeeper, and if she felt the change coming in the midst of a sale, she would record the amount of the purchase or of the money that she had received that she might continue the transaction without mistake when the new self appeared.

The Nature of Dissociation. — So far as present knowledge extends, it seems that the cause of the dissociation of the self is to be found in a disturbance of the connections between the experiences. An emotional shock breaks the associations between masses of neurones that correspond to groups of memories. After the shock, an event in one group will recall other members of that group alone; the recall will not extend to the memories dependent upon the other group. Also and more important for the explanation of the active self, the acts and thoughts and emotions will be controlled at any moment by the experiences that belong to one group; elements from the other group will have no effect upon action at the times the other group is dominant. The acts of the one self, or group of experiences, will be consistent, but the acts of one self will not be consistent with the acts of the other self, or group of experiences. When the connections between different experiences are broken, the disappearance or the modification of qualities ordinarily attributed to the self is strong proof that the

self in the normal individual is largely determined in its character by the way the different experiences interact. This series of connections gives continuous memory, makes the experiences of any moment a unit, and through directing thought and act keeps the self of one moment consistent with the self of other moments.

Minor Forms of Dissociation. — Slighter signs of alternating selves may be found in normal individuals. The hypnotic condition differs from the normal very much as one of the dissociated selves differs from another; and selves may be induced in the hypnotic state that are related in every practical respect, as are the dissociated or alternating selves. In the normal state one seldom has memories of the hypnotic state, and by suggestion during hypnotism it is easy to change the character of the self, practically at will. Similar normal divisions in the self may be seen in the life of any individual. The ordinary business man is one man at home, and another in his place of business. He thinks differently, and acts differently. Of course here the dissociation is restricted to the control of action; memory is continuous, and the actions are not sufficiently different to prevent the man from being recognized as himself. It is very interesting to note that various groups of responses are aroused on relatively slight suggestions. Frequently men undergo changes as they change their surroundings. A man may be perfectly at his ease in his own home, and very much embarrassed or very diffident when in a strange place. Clothing frequently plays a considerable part in suggesting selves or groups of responses. All one's self-possession may be destroyed if one finds one's self in company without some usual article of apparel, a cravat, for example. Manners frequently are put on with the gar-

ments. It is said of Stanley, the African explorer, that his ability to make a speech depended upon his wearing a small cap that had been given him by Livingstone. When called upon to reply to a toast, or when lecturing, he invariably donned this cap. Without it, he seemed tongue-tied. Many lecturers feel lost without a reading desk even if they never use notes, and the absence of some familiar article of furniture may destroy their composure. In each of these cases, the familiar situation or the familiar article arouses a group of experiences that will not be present without it. The actions grow out of the experiences. When all of the usual accompaniments are present, the course of thought and speech or act runs smoothly; without some apparently insignificant element, the whole complex is disturbed.

The Self a Social Product. — One is aware of the character of the effective self altogether through the social relations. Were it possible for a child to grow up alone, he would have no appreciation of his character. He would not know whether he were quick-tempered or slow to anger, whether he were honest or dishonest, strong or weak. The questions that grow out of the self problem would not occur to him. All of these characteristics of the self are appreciated only when there is a chance to compare himself with others. He knows himself only as he sees himself reflected in the opinions of others. This statement is the converse of the other statement, that man knows others or at least the mental processes of others only in so far as he can interpret their acts in terms of his own conscious states. The processes of knowing one's self and of knowing others are correlative. Each can be known and appreciated only in the light of the other. One passes judgment on the acts of others and then compares his own acts with them, to obtain

the judgment of himself and of others upon himself. What is constantly dominant in the idea of the self is the impression that others have. One holds one's self at the estimate others have or are imagined to have.

The Self a Concept. — For psychology, the notion of the self is a concept similar in origin and development to any other. The elements about which the concept centers are the organic and other persistent sensations. These elements are closely connected with the original egoistic instincts and receive constant additions by the development of new ideas and new habits. The concept probably always represents activities rather than mental states. In its developed form it is the representative in thought of the continuity of consciousness, of the fact that the different experiences all belong to the same individual, and that the acts of the individual are consistent at all times. The occasion for the development of the concept is largely social, as the need for the idea is social. Society must know to what extent an individual is to be relied upon and how he will act in all respects in any set of circumstances. The self is society's way of formulating this knowledge. It is important, too, that the individual should know how he is regarded, and for his own benefit should know what he is likely to do in any situation. These needs have led to the development of the notion of the self with all that it implies.

Thus for psychology the self is a concept to be traced to its sources, — is one phenomenon among others to be explained as best we may, but such a treatment will never be satisfactory for any one else. What for the psychologist is just one problem on the same level as any other, is for the layman or for any one in a non-psychological attitude the very core of his being. From it irradiate all desires, its

advancement is the goal of all egoistic instincts, it is the center of nearly all our joys and sorrows. To it are referred all of our purposes in life, its exaltation is the object of most of our activity. All social and physical events are measured by their effects on our personal ambition and personal welfare. As the occasion of solicitude in all of our social and religious aspirations, the self takes on a value that makes any scientific analysis seem entirely inadequate and even presumptuous. The treatment of the psychologist grows out of his peculiar methods and needs, and much still remains to be done even to attain his end in his own way. The answers it gives must be unsatisfactory to the popular mind, for the problems that most interest it lie far afield for the psychologist. They can be approached to advantage only by the methods and on the assumptions of ethics, metaphysics, and religion. On these problems psychology has nothing to say, since the limitations of its methods and its knowledge give it no right to an opinion.

QUESTIONS

1. Under what circumstances and for what end does the idea of self develop?

2. Would you have your present idea of self if you had chanced to survive alone on a desert island?

3. What do you have in mind as you think 'I' (*a*) when striving to win in a wrestling match? (*b*) when you think of a rival for a class honour? (*c*) when conversing in a congenial group?

4. What is the relation of the 'self' to the other psychological processes? to will? to emotion? to attention? Are they whole and part or independent partners?

5. What gives consistency to the actions? What do you mean when you say you were not yourself in a certain emergency?

6. What do you mean by continuous self-identity? What makes it possible?

7. How are these last two functions disturbed in a dissociated personality?

8. Is it more nearly true to say that for modern psychology there is no self or that man is all self?

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CHAPTER XVIII

TYPES OF PSYCHOLOGICAL THEORY

In this book we have given an outline of psychological facts with no special attempt to connect them with a particular general theory. This neglect has been intentional on the part of the author, as he believes that facts are common and impersonal, while theories are individual and bound to change with advancing knowledge, and still more with the bias that comes from special experiences on the part of the writer or from biases developed from standpoints assumed in other sciences or in connection with general theories of life. Of course these general theories cannot be altogether avoided and probably have crept in at times in the preceding discussions. That the reader may become acquainted with the main points of approach to psychological facts, it may be well to give in brief summary the more important general theories now prominent.

All theories may be divided into the animistic and the materialistic as the rough extremes, although there are many combinations and compromises to make each extreme more plausible, more in harmony with accepted fact. The animistic theory makes fundamental a spirit or soul force. In the crudest forms this is a mere acceptance of the whole man robbed of all material parts and is taken, as the child thinks of his will or intention, as possessing reality and force. It can never be stated or even thought quite clearly, for one never can quite abstract from the material in thinking of

one's self. It is always somewhat mystical, for the force it assumes cannot be measured or translated into anything else. The materialistic way of thought, on the contrary, would reduce all to the merely physical and chemical forces and bits of matter, although in the modern systems the elements of matter are reduced to force. There would be nothing, ultimately, but electric charges with their mutual attractions and repulsions. The phenomena we call mental would be in some way reduced to or derived from these ultimate forces and their interactions.

The Greek Atomists and Animists. — The most consistent representatives of each of these theories are found among the Greeks. Then knowledge was so slight that one might be consistent without obviously coming into conflict with observed fact. The atomists, represented by Democritus, were most consistent. For Democritus all bodies were made up of small indivisible particles with empty spaces between. They were all in rapid motion. The soul was composed of similar particles. These differed from the body particles only in that they were finer, more round and in more rapid motion. They were interspersed everywhere between the body atoms. Plato made specific a view that earlier men had held more vaguely that a thought process might be independent of body and in many respects be the dominating force that controlled it. Plato assumed the existence of ideas as independent realities, which dominated rather than depended upon the body. They existed before the body and had sources of knowledge independent of the sense organs. Aristotle developed a notion of the relation between the mental and the physical that is the prototype for most of the moderns who would make the mental aspects dominant. Aristotle gave full importance to the body,

but assigned a determining place to the purposive directing force that he called form or entelechy. Matter had laws of its own, but the final control was always through the more mental activity which was guided by a desired end rather than by mere mechanical laws.

Descartes and the Opposition of Mind and Body. — The method of picturing psychological problems that has been prominent in recent times was first clearly stated by Descartes. Descartes asserted that there were to be distinguished a thinking substance, or mind, and the body. The mind was located in the pineal gland in the center of the brain. It moved the body by sending animal spirits through the nerves to the muscles that were to be used. Similarly it was affected by the animal spirits that were sent to the pineal gland by the sense organs and from other parts of the body. The thinking and conscious processes were restricted to this mind and could be directly known. The problem which Descartes set was at once attacked by different groups of men, and in the course of half a century practically all the types of solution of the problem, so far at least as they have been developed at all, were presented. Descartes' own position is the analogue of what we know as the theory of interaction. It asserted that body acted on mind and mind acted on body in the same way that one body acted upon another. Spinoza, who next attacked the problem, believed that mind and body were not to be regarded as distinct, but were merely phases of one common substance. He thought the common substance was God, and that He manifested himself in two ways. In one phase, He appeared to the senses as body, in the other He appeared to the man himself as mind. All real causes acted within the common substance, so there

could be no difficulty about how mind influenced body and body mind. This is typical of the so-called double-aspect theory of body and mind, which has taken many forms since Spinoza and is still held by many thinkers.

Leibniz and the Parallelist Theory. — Leibniz, a contemporary of both Descartes and Spinoza, also developed a way of avoiding the necessity of regarding mind and body as acting directly upon each other. His philosophical theory assumed that the universe was composed of monads, which were at the same time thinking existences and things. They were created at the beginning and always mirrored the events that went on in the universe outside, simply because the ideas of each developed at the same rate as did events in the world. Consequently, man who was one of the highest monads, always had perceptions of what was occurring outside, although the perceptions were not caused by the events, but merely developed at the same time the events happened. This doctrine developed into the so-called doctrine of psycho-physical parallelism, which was held by Wundt and others. The modern men do not believe in monads, but they do believe that mind does not act on matter, nor matter upon mind. Still events in the mental world go on at the same time as the changes in the nervous system to which they correspond. The three theories — interactionism, the double aspect theory, and parallelism — seem to exhaust the ways man has developed of representing the relation between mind and body.

The English thinkers were from the first more interested in tracing the laws that held between the different mental processes than in the general problems of the nature of mind and matter. Hobbes, Locke, and Hartley first attacked the problem by observation. They found in common that

the earlier connections, what have since been called associations, could be shown to determine the order of return of ideas. They explained memory and ideational processes in general by the use of these simple connections. The English and Scotch writers, Hamilton, the Mills, Bain, and many others of the same school continued the investigations and extended them along the same line. With increasing knowledge of the bodily structures they extended the studies to include the voluntary and emotional processes, as well. The interpretations of these processes, too, were along the lines of association.

In Germany, Herbart made an attempt at an analysis, coupled with a deductive theory that would relate the observed phenomena to the interrelations of ideas. His work was an interpretation of what mind would be like if all depended upon the relations of ideas as independent forces which might either aid or check the activity of each of the others. He explained the phenomena of attention on the assumption that if a group of ideas already in mind was in some way similar to others that were presenting themselves, they would aid the entrance of that idea and check others that were not in harmony with it.

The modern psychology that continues down to the present began from the bringing together of the work of the physiologists on the sense organs and reflexes, the study of the nervous system by anatomists and physicians, together with the work of the older psychologists on association and related processes. Many contributed to this end, but the work may be said to have culminated in the foundation of a laboratory of experimental psychology at Leipzig by Wilhelm Wundt in 1878. Here experiments were carried on systematically on all of the phases of mental life, and the

interpretations were expanded to combine those of the earlier sciences and the theories of the associationists and Herbart.

A little later William James, who had started his work as a physiologist, transferred his interest to psychology, and became Professor of that subject at Harvard. He contributed the theory of emotions that we have mentioned and many brilliant analyses of topics ranging from memory to the self.

Structuralism. — At present five general ways of looking at the material of psychology may be distinguished. The first of these is the structuralist. It makes its problem the description of consciousness and the analysis of the mental states, after the manner of the naturalist and the chemist. The method used is primarily introspection. You watch the mental state as you would an external object. By experimental means you can change the stimulus, and can also change your attitude and note how the mental process changes. The structuralist covers the whole range of problems that we have discussed, but with emphasis upon the qualities of sensation and mental images during recall and thinking, and the constituents of feeling and emotion and the antecedents of action. Titchener was the most prominent representative of the school.

Functionalism. — The second in order of development of these recent theories is the functionalist. As the name implies, the functionalists insist that psychology should study, not mental states, but the functions of the mind or of the man. One may not know what one has in consciousness when one thinks of a friend or of an abstraction such as force, but still be sure that he is thinking of it and reaching proper conclusions concerning it. One can study the

laws of recall and of learning and neglect entirely the purely structural mental processes. The functionalist does not deny them to exist and considers them where they have value in explaining the function, but his emphasis is upon what consciousness does rather than upon what it is. Angell under the influence of Dewey was mainly responsible for the development of this theory or attitude.

Behaviourism. — Differing from functionalism mainly in taking the next step and denying the existence of consciousness is behaviourism. If functionalism asserts that the psychologist need be interested only in what the individual can accomplish and how he does it, behaviourism insists that we can know only what man does, and that only as seen by another. Watson, who formulated the doctrine, began as an animal psychologist. In working with animals, one can only study their responses in a given set of conditions. It is useless to ask what the mental antecedents of any act are, if there are any, because the animal cannot tell you, and there are no other avenues of approach to consciousness. The animal psychologist is always being asked 'do animals think?' a question no man can answer. The animal psychologist soon laid it down as a principle of explanation that animal processes must be explained in terms of nervous and environmental conditions only. He saved himself worry by refusing to ask whether the animal might be regarded as having mental states intervening between the stimulus that was applied and the response that he made.

Jennings, who worked mainly with the activities of the lowest forms of animal life, early applied to their movements taken as a whole the term behaviour. Watson suggested that the same term might well be applied, first to the activities

of the higher organisms, and then of man. One must think of the activities of an amœba as due to the stimulus acting upon a highly complicated mass of chemical substances, and of the act as altogether determined by the interaction of these forces and conditions. One may also think of man as a more complicated mechanism made up of many such simple organisms, and of its activities as the sum of the potentialities of the separate members of the colony. Watson insisted that one should make no use of any knowledge that the individual studied may have of his own motives, or of any consciousness that might precede action. The psychologist should study other men, just as he studies animals, from the outside. In fact he went further and insisted that man no more than the animal has any consciousness, and so concluded that the man studied had nothing to contribute to the data furnished by the stimulus and his responses.

Even the responses of the organism were very much simplified. The list of instinctive responses was very much reduced, all the innate tendencies were limited to fears of the simplest form and the primitive reflexes. The only law of action of earlier environmental factors recognized was the conditioned reflex, described on p. 146. This permitted the transfer of the response normally aroused by one stimulus to another that chanced to be applied frequently at the same time as the first. Behaviourism limits psychology to studying the responses called out by the stimuli applied at birth and those that may be acquired by substitution in harmony with this simple law of learning. Recently the emphasis has been altogether upon these acquired responses, and native connections have been reduced to a minimum or denied altogether. Even the emotions are referred alto-

gether to learning, aside from the native responses of the ductless glands.

Consciousness or something that does duty for it is introduced indirectly as a series of slight movements. The most important of these are the movements of the vocal organs, the movements that, when more pronounced, give rise to speech. It is not asserted that these movements have any function in arousing other movements or in modifying responses in any way. As there is no consciousness attaching to them more than to other responses or stimuli, and they are too slight to be noticed by the onlooker, they seem to have no real function. They are emphasized as in some mysterious way important for the man. On the whole, behaviourists do not raise the question of how man knows.

Animistic Theories. — A revival of the animistic doctrine has been urged by MacDougall. He insists that mind as a force must be taken into account in addition to the action of the nervous system and all chemical and physical forces. It is practically a complete return to Aristotle. Mind is Aristotle's ' form ' that, of its own volition, works changes in matter. For the modern animist, mind is the determining factor in all of the selections to which we have assigned the name of subjective influences in attention, in the selection of ideas in recall, and in the development of perceptions. It would also be the initiating and vitalizing as well as selecting agent in the control of action. It is practically identical with the will of common sense or popular speech. The difficulty with the introduction of the notion is to be found in the fact that it has no conditions, it is an unmoved mover. No laws can be given to it, or at least are given to it. This means that introduction of the term does not serve in any way to make clearer why any of

the mental functions take the course that they do. At the best it is a factor that merely sets a limit to our explanations; it cannot itself be an explanation. It is much better to explain as far as we can in terms of conditions that can be stated in definite terms and might conceivably be measured and then to say that we do not know as to the rest. For to talk of mind as a force in explanation of concrete action is no more than to assert that things happen for reasons that we cannot make clear. This is the equivalent of saying that we do not know why they take the course that they do. The school is a return to the ancient animism.

The 'Gestalt' School. — The last school to become prominent is known, from the word they used most frequently in the explanation of one of their early problems, as the 'Gestalt' group. This is the German word for form. It was applied because the theory was first stated in an attempt to explain why we saw movement when two lines in different positions were presented at suitable intervals. None of the particular explanations that had been mentioned previously, or any others that they could think of, seemed satisfactory, so Wertheimer suggested that the perception of motion was dependent upon the entire form in which the lines were presented. In general the school denies that analysis of a situation or mental state into its elements constitutes an explanation for psychology. Rather, mention of the entire unity of experience, of which the particular is a member, constitutes the only explanation.

The later extensions of the theory give it much in common with the animistic theories. The whole or form comes to mean the whole mental constitution of the individual and so to mean mind as opposed to nervous system or even parts of consciousness. In explaining the learning of apes, Koeh-

ler, who is one of the most prominent representatives of the system, insists that apes learn not by trial and error, but by insight. They see the whole, of which the particular instruments constitute parts, and this awareness of the whole makes trial and error learning unnecessary. Other exponents of the system assert that the selections under the influence of attitudes and context, which we have emphasized both in attention and in recall, are the outcome of the active whole. The controlling factors are not to be analyzed as we have done into particular earlier experiences or into groups of earlier experiences.

Rather we must assert that the mental operation is the expression of the unitary mind. Analysis is unnecessary, and even misleading, as it tends to distract from recognition of the importance of the whole. In this phase of its application, the ' Gestalt ' theory emphasizes, as we have, the importance of the wider phases of the individual in controlling all types of selection and interpretation. The difference lies mainly in the fact that we have shown that particular elements in the wider experience are effective in each of the concrete cases. The configurationists, or members of the Gestalt school, on the contrary, would explain all by the single phrase, the whole is superior to and controls its parts. All specific indication of how or where the parts are controlled is superfluous. This phrase we would consider but the starting point of a series of investigations that should attempt to develop a concrete explanation. They regard it as the final explanation to be no more questioned, or even expanded.

Different as are the tenets of these various schools, they diverge for the most part in the explanations that are given to certain accepted phenomena of life, rather than in the

description of the phenomena and the statement of their laws. The structuralist and the functionalist differ mainly in the emphasis they put upon different phases of the conscious experience. The structuralist gives more attention to the description of the concrete conscious phenomena, while the functionalist is mainly content with taking these for granted and asking why they are as they are, or why they follow the order that they do, and particularly why the man behaves as he does. Most different from the others are the behaviourists. They eliminate from the textbook on psychology a large part of the material on sensation, or perception, memory, imagination, and reasoning, with only so much of feeling and emotion left as can be deduced from effects of the glands upon the organism. Even here the modification of activity that comes from possessing sense organs of different kinds would find a place in a complete explanation of behaviour. The modifications of interpretation put upon external objects because of different antecedent experiences would reveal themselves in behaviour. Memory could be studied objectively, and even the conclusions drawn in reasoning have their effect upon human action. Ultimately behaviourism would need to study these phenomena, and might study them objectively even without translating mental states into movements of the tongue where they are lost altogether from their fundamental assumptions.

The animistic and 'Gestalt' theories would not eliminate anything from the subject matter of psychology. They differ from the position that has been taken in the text only by asserting generally that all variations from strictly mechanistic explanations are to be explained by the activity of mind rather than left unexplained. It is a question

whether to say ' I don't know ' is not as much of an explanation of a choice when it can no longer be traced to antecedent mental and physical factors, as to say mind did it or that it is an outcome of the action of the unity of experience or of the entire configuration, upon a particular act or process. Whether we agree as to what constitutes an explanation or not, it is possible to agree on the specific facts, and upon the more important causal forces in inducing the changes. That will suffice for the making of a science. The ultimate explanations, here as in other sciences, will come after the observations have been made and the preliminary interpretations given. These must change and the more variety in the suggestions, the greater the chance for the final attainment of a satisfactory general formulation or theory.

QUESTIONS

1. What are the fundamentally opposite explanations of mental life?
2. Outline the picture of the relation of mind and body introduced by Descartes.
3. How did the associationists explain memory and thought in general?
4. Who founded the first psychological laboratory? Where was it?
5. From what sciences did psychology develop?
6. Compare the way in which the functionalist and the structuralist would view an act of attention.
7. What part of man's life does the behaviourist emphasize?
8. What phases of experience does the behaviourist neglect?
9. How does the animist explain a decision?
10. How would a member of the 'Gestalt' school explain learning in an animal? perception of a word?
11. How do animism and the 'Gestalt' school resemble each other? How do they differ?

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